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A revision of the genus *Vorticella* (Ciliophora: Peritrichida)

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Introduction

Anyone who has had experience with the identification of free-living ciliates will be familiar with the difficulty of distinguishing the species of *Vorticella*. Their plastic body shape, variable size and highly contractile nature has made them among the most difficult of ciliates to study and identify. This has resulted in the erection of numerous species and varieties many of which are of doubtful taxonomic status.

The last major revision of the genus *Vorticella* was that of Noland & Finley (1931) who found in the literature over 200 names and descriptions. Many were clearly not congeneric, the majority being either rotifers or other protozoa but even after the rejection of these, some 94 nominal species still remained. Over the intervening 50 years another 113 species and varieties have been added giving a total of 209. With so many taxa, the descriptions of which are spread throughout the literature, the task of the ecologist trying to identify individual isolates has become particularly onerous even with the aid of identification keys such as those of Stokes (1885*a*), Kahl (1935), Curds (1969), Stiller (1971) and Green (1974).

The aim of this paper is to provide both the ecologist and the specialist in peritrichs, with a functional classification of the species of *Vorticella*. For this purpose Noland & Finley (1931) have been imitated in that a checklist of the 209 named taxa has been compiled and the taxonomic status of each determined. Drawings and descriptions of the extant species of *Vorticella* are given and a key to their identification has been constructed.

Systematics

In the scheme adopted by the Committee on Systematics and Evolution of the Society of Protozoologists (Levine *et al.*, 1980), based on the classification of Corliss (1979), the taxonomic position of the genus *Vorticella* is given as follows:

Subkingdom:	Protozoa Goldfuss, 1818 emend. von Siebold, 1845
Phylum:	Ciliophora Doflein, 1901
Class:	Oligohymenophora de Puytorac *et al.*, 1974
Subclass:	Peritrichia Stein, 1859
Order:	Peritrichida Stein, 1859
Suborder:	Sessilina Kahl, 1933
Family	Vorticellidae Ehrenberg, 1838
Genus:	*Vorticella* Linnaeus, 1767

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Diagnosis

The following list of characters serve to define the genus *Vorticella*. Body borne upon a contractile stalk, always solitary although many species are gregarious. Zooids commonly inverted bell-shape but may also be spherical, cylindrical or cone-shape. Oral cilia in three rows, two inner (polykineties) and one outer (haplokinety) which wind counter-clockwise around the peristome when viewed from above. Somatic cilia absent in the normal adult cell. Each zooid contains a single macronucleus accompanied by a small, oval micronucleus. The macronucleus is typically long and sinuous. Impregnation by silver reveals a pattern of equally spaced horizontal lines which encircle the body. The stalk is oval in cross-section and contains a helically coiled contractile myoneme called the spasmoneme which causes contraction to take place in a spiral not a zig-zag manner. Asexual reproduction is by binary fission with one cell remaining attached to the stalk while the other becomes the migratory telotroch which has an extra row of cilia, the aboral ciliary wreath, near the aboral pole. Sexual reproduction is by conjugation and involves total fusion of the mobile microconjugant with the sessile macroconjugant.

Taxonomic characters

Traditionally the taxonomy of the vorticellae is based on the morphology of the living organism as revealed by light microscopical examination. The principal characters used are shown in Figure 1. In recent years special techniques such as silver impregnation, scanning and transmission electron microscopy (SEM & TEM) have been increasingly used to study pellicular and sub-pellicular structures in greater detail (Hobbs & Lang, 1964; Reid, 1967; Kawamura, 1973; Barlow & Finley, 1976*a*; Foissner, 1979; Carey & Warren, 1983). As a result the taxonomic importance of structures such as the pellicular striations, pores and tubercles has increased accordingly. Furthermore evidence is accumulating that ecological and behavioural factors such as host specificity (for epibionts), substrate preference, pseudocolony formation and telotroch swimming patterns may also be useful diagnostic characters (Nenninger, 1948; Barlow & Finley, 1976*b*; Horikami & Ishii, 1981). The most important taxonomic features are discussed below and it is recommended that as many of these as possible should be considered when describing a new isolate.

BODY SHAPE. The outline form is the first and most readily recognisable feature of the *Vorticella* zooid. Although commonly inverted bell-shape, a range of body forms occur throughout the genus including species which are spherical (*V. globularia, V. sphaerica*), cylindrical (*V. aequilata, V. elongata*) and conical (*V. kenti, V. patellina*). This variety of form introduces a problem of definition since the interpretation of body shape can be highly subjective: what is elongate to one observer can be ellipsoidal to another. Methods of quantifying body shape for more objective mathematical analyses were investigated by Roberts *et al* (1983). It should also be noted that the body contour of some species is readily changeable (e.g. *V. inconstantans*) and that nearly all vorticellae alter their shape as conditions change in a culture or in a drop under examination. In view of this only freshly isolated and healthy specimens should be used when describing body shape.

SIZE. Size is usually expressed in terms of the overall length and maximum width of the zooid. The length is measured from the scopula, i.e. the stalk–zooid junction, to the upper rim of the peristomial lip and the width is measured at the widest part of the body below the peristome. There is often considerable variability within, and overlap between the various taxa in terms of size, and dimensions are frequently given as average values within defined ranges. Kahl (1935) has suggested that size ratios, such as zooid length: zooid width or peristomial lip width: zooid width, might be a more useful method of expressing these dimensions. Clearly, taken alone size does not constitute a particularly secure criterion of species but it does serve to reinforce other more distinctive features.

COLOUR. There are three main sources of colour within the zooid; the cytoplasm, the contents of the food vacuoles and cytoplasmic inclusions. The first two were rejected by Noland & Finley

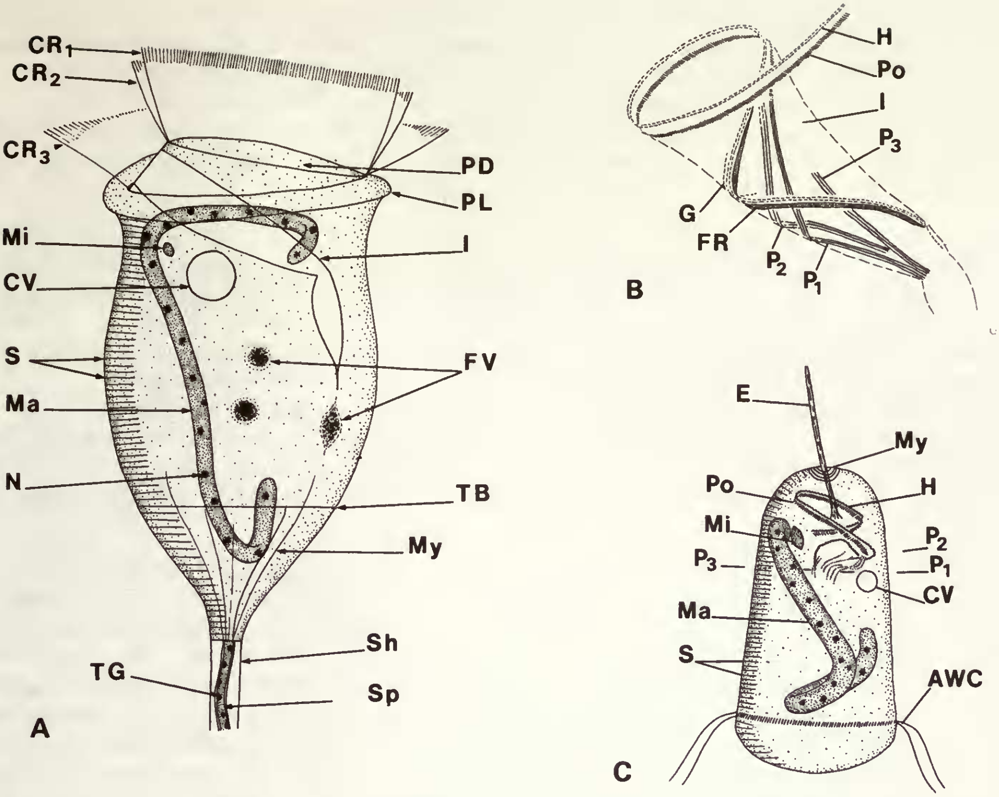

Fig. 1. A generalised *Vorticella*: (a) zooid; (b) buccal infraciliature; (c) telotroch. AWC aboral wreath of cilia; CR$_{1-3}$ 1st, 2nd & 3rd ciliary rows; CV contractile vacuole; E epistomial membrane; FR filamentous reticulum; FV food vacuole; G germinal row of kineties; H haplokinety; I infundibulum; Ma macronucleus; Mi micronucleus; My myoneme; N nucleolus; P$_{1-3}$ 1st, 2nd & 3rd peniculus; PD peristomial disc; PL peristomial lip; Po polykinety; S striations; Sh sheath; Sp spasmoneme; TB telotroch band; TG thecoplasmic granule.

(1931) as being of little taxonomic significance since both are known to vary in colour according to ecological conditions and food source respectively. The cytoplasmic inclusions consist of endosymbiotic zoochlorellae, waste and reserve granules. Noland & Finley (1931) recommended that species diagnoses should be established on grounds other than the presence of intracellular zoochlorellae pending further studies on the stability of the symbiotic relationship. Following their ultrastructural studies of two species of *Chlorella*-containing *Vorticella*, Graham & Graham (1978 & 1980) concluded that the relationship is stable and that the presence of endosymbiotic zoochlorellae may be accepted as a reliable taxonomic character.

PERISTOMIAL LIP. The peristomial lip, also referred to as the peristome border or bell margin, is the contractile rim that encompasses the anterior end of the cell. Upon contraction the lip constricts enclosing the peristomial disc and cilia which are withdrawn below. The peristomial lip usually takes the form of a simple rim but in some species, such as *V. campanula*, it projects from the periphery of the body in a shelf-like manner while in others it is ornamented by frill-like undulations (*V. cratera*), spine-like projections (*V. pulchra*) or tubercles and granules (*V. vernalis, V. verrucosa*).

The diameter, thickness and degree of eversion of the peristomial lip have a considerable influence on the overall appearance of the zooid and are commonly included in species descriptions. However, Noland & Finley (1931) highlighted the variability of these parameters with changing environmental conditions observing that 'nearly all vorticellae alter the degree of eversion and even the width of the border as conditions change in the surrounding medium'. They concluded that the variability of the lip was too great to justify placing much weight on it. Conversely, in a study of symphoriont peritrichs, Vavra (1961) found that the peristome remained constant over a range of environmental conditions. Clearly further studies on variability are required but it is generally accepted that the peristomial lip of a healthy, freshly mounted specimen constitutes a useful diagnostic feature.

PERISTOMIAL DISC. The peristomial disc (epistomial disc) is the area at the apical end of the cell encircled by the rows of cilia. In some species (e.g. *V. bivacuolata, V. elongata*) the disc is typically arched high above the peristome whilst in others it is flattened or only slightly elevated. It has been reported that most species react to unfavourable conditions by becoming increasingly globular and developing a protruding disc (Noland & Finley, 1931). Therefore the shape of the peristomial disc should only be described for healthy, freshly mounted specimens.

Silver staining reveals the presence on the disc of concentric rings of silver lines similar to those found on the rest of the zooid (Klein, 1926 & 1927) although these have not been studied in detail. Ridges or undulations radiating from the centre to the periphery and pellicular secretions may also be present but these are considered to be transitory features of little taxonomic value (Noland & Finley, 1931).

MACRONUCLEUS. *Vorticella* has a single macronucleus which is typically long and sinuous. The shape and position within the zooid of the macronucleus are useful diagnostic features although variation throughout the genus is limited. The two conformations most commonly found are J- and C-shaped. The J-shaped macronucleus lies longitudinally with respect to the major axis of the zooid, its upper arm curved horizontally across the peristome and its distal end bent upwards (Fig. 1). The C- or horse shoe-shaped macronucleus is often shorter and is usually situated in the central or anterior part of the zooid. Its orientation may be either longitudinal (e.g. *V. longifilum, V. pulchra*) or horizontal (e.g. *V. striata, V. communis*) with respect to the major axis of the zooid. The length and degree of curvature of the C-shaped macronucleus vary considerably from short and only slightly curved (e.g. *V. exilis*) to highly elongate and curved in a ring-like manner (e.g. *V. operculariformis*). Some vorticellae have macronuclei which are irregular in shape (e.g. *V. muralis, V. nutans*) while in others (e.g. *V. macrophya, V. quadrangularis*) the macronucleus has yet to be described.

Macronuclei are readily demonstrated using standard nuclear stains such as the Feulgen Reaction (Mackinnon & Hawes, 1961) and methyl green (Curds *et al*, 1983). The macronucleus is usually accompanied by a small, oval micronucleus. The micronucleus shows little variety among the different species and is difficult to observe in the living animal. Therefore it is not considered to be a particularly useful diagnostic feature.

BUCCAL APPARATUS AND CILIATURE (Fig. 1b). Infraciliary buccal patterns, which have been extensively studied in most ciliate groups and often with far reaching taxonomic consequences, have received comparatively little attention among the peritrichs. A notable exception was the exhaustive study carried out by Lom (1964) and it is from this work that much of our current knowledge is derived.

The ciliature of the adult *Vorticella* zooid is confined to the anterior end of the cell. It consists of three rows of cilia, two inner rows or polykineties (PO) and one outer row or haplokinety (H). These are situated around the edge of the peristomial disc where they perform a 1–1½ turn of the peristome before plunging down into the infundibulum. Here the two separate, the PO passing directly downwards whereas the H follows the border of the infundibulum before sinking downwards. The PO and H are now 180° out of phase as they continue their counter-clockwise spiral down the funnel-shape infundibulum (Fig. 1b). At the base of the infundibulum is the cytostome which leads to the cytopharynx. The cytopharynx is a non-ciliated tube-like structure not usually visible in the living animal although its length and position can be ascertained by watching food vacuoles pass through. The overall length and orientation within the cell of the infundibulum and cytopharynx are often included in species diagnoses. However, Lom (1964)

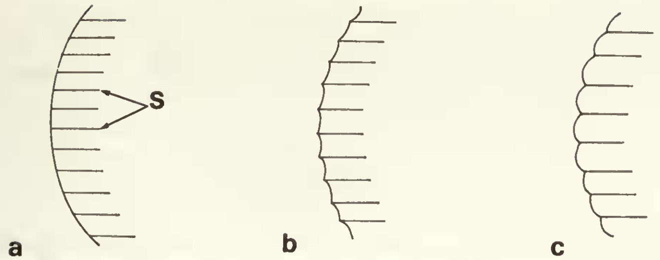

Fig. 2. The three types of ribbing between the striations (S) on the pellicle of *Vorticella*: (a) normal; (b) concave; (c) convex (b & c, after Foissner & Schiffmann, 1974).

concluded that the uniformity of peritrich buccal structures limits their use in the differentiation of closely related species.

CONTRACTILE VACUOLE (C.V.). Most vorticellae have a single c.v. and this is usually situated just beneath the peristome, close to the infundibulum. In some species a second c.v. is present and this is also located in the anterior part of the cell usually on the opposite side of the infundibulum to the first c.v. Thus while the position of the c.v.(s) is comparatively uniform throughout the genus, the number of c.v's per zooid is a useful diagnostic feature. It has also been suggested that the diameter and rate of pulsation of the c.v. may be valuable aids for distinguishing species (Noland & Finley, 1931). However these parameters should only be considered in the light of the osmotic conditions of the surrounding medium.

PELLICLE. The structure of the pellicle of *Vorticella* corresponds closely with that of other ciliates. It consists of a single plasma membrane overlaying a system of membrane-bound alveolar sacs which in turn lie between transversely orientated pellicular ridges (Kawamura, 1973). In many species these ridges are well developed and are clearly visible under the light microscope as transverse striations encircling the body. These striations, along with the pellicular pores which are also found all over the zooid surface, have become increasingly important in peritrich taxonomy in recent years. Special techniques such as silver staining and SEM have been employed to study pellicular structures in detail (Hobbs & Lang, 1964; Small & Ranganathan, 1970; Davidson & Finley, 1972; Barlow & Finley, 1976*a* & *b*; Carey & Warren, 1983). The distribution patterns formed by the pores and striations have been analysed biometrically (Reid, 1967; Foissner & Schiffmann, 1974 & 1975; Foissner, 1979 & 1981).

Further variations in the pellicle occur in those areas between the striations. For the majority of vorticellae the pellicle in these areas follows the contour of the zooid when the animal is viewed in profile. However in some species the pellicle curves inwards while in others it bulges out (Fig. 2). Foissner & Schiffmann (1974) referred to these two pellicle types as concave and convex respectively. The configuration of the pellicle between the striations, or 'ribbing', is determined by the shape of the underlying alveolar sacs.

Other pellicular structures which are rather less common and are found in relatively few species include tubercles (e.g. *V. perlata*), spines (*V. voeltzkowi*), mucus layers (*V. rhabdophora*) and membranous sacs (*V. vestita*). Although the functions of these structures are generally not known, they are useful characters for recognising species.

STALK. The stalk is probably the most characteristic structure of *Vorticella*. A comprehensive study of its ultrastructure was made by Randall & Hopkins (1962) but basically it consists of an outer wall or sheath enclosing a fibrillar matrix which supports a contractile cord. The cord consists of a membrane-bound layer of cytoplasm, or 'thecoplasm', and placed excentrically within this is the contractile myoneme or 'spasmoneme'. The thecoplasm often contains numerous small refractile bodies called thecoplasmic granules which lie alongside the spasmoneme in longitudinally arranged spiral rows. When present, these granules are usually colourless but in two species (*V. picta* and *V. rubristigma*) they are coloured either green or red. The function of the thecoplasmic granules is not known and in several species they are absent altogether.

Stalk length has long been used as a diagnostic feature for species of *Vorticella*. However although stalk length does tend towards a modal value in many species, individual variation is too great to justify much taxonomic reliance. Other parameters which appear to be more consistently uniform are stalk width and the length of one complete turn of the spasmoneme spiral, i.e. the internode distance. Noland & Finley (1931) found a direct mathematical relationship between the two, the internode distance being approximately ten times the stalk width.

The stalk sheath shows some variability within the genus. For most vorticelliae the sheath is untwisted when the stalk is fully extended but in a few species (e.g. *V. flexuosa* and *V. gracilis*) it is twisted and in some cases has an even greater spiral curvature than the contained spasmoneme. Occasionally the sheath may also have distinct rings or annulations (e.g. *V. annulata*). According to Noland & Finley (1931) these annuli represent points of cell division and are transitory features of little taxonomic value.

TELOTROCHS. The telotroch is the free-swimming stage of the *Vorticella* life cycle and is formed as a result of asexual reproduction (binary fission). Telotrochs are usually cylindrical or cone-shape and possess an extra row of cilia, the aboral ciliary wreath, near the scopular region (Fig. 1c). They swim with the aboral end facing forwards and the peristome, which remains closed, facing backwards.

Although studied in relatively few species, telotrochs exhibit several potentially useful taxonomic characters, both morphological and behavioural. Morphological features of diagnostic value include size, shape and pellicular structures. Telotroch behaviour is even less well documented than morphology, a notable exception being Barlow & Finley's (1976*b*) study of swimming patterns and settling activities of four *Vorticella* spp. It was noted that each of the four species had its own characteristic behaviour pattern.

It has long been known that certain species of *Vorticella* form pseudocolonies while others remain solitary (Kent, 1880–1882; Spoon, 1974). Horikami & Ishii (1981) reported that the adult zooids of pseudocolony-forming species such as *V. convallaria, V. campanula* and *V. vestita* secrete a transparent viscous compound which acts as an attractant to the telotrochs. As a result of this positive chemotactic response the telotrochs settle on the substrate close to the attached adult cells.

CYSTS. Cysts and the processes of encystation and excystation have been described in detail for only one species, *V. microstoma* (Brand, 1923; Finley & Lewis, 1960). The presence of cysts has been reported in few other species. Although Corliss & Esser (1974) have highlighted the importance of cysts in peritrich ecology, our knowledge of the *Vorticella* cyst is meagre and its taxonomic application has yet to be explored.

ECOLOGICAL FACTORS. It has long been recognised that different species of *Vorticella* often have a predilection for different ecological conditions (Kolkwitz & Marsson, 1909; Noland, 1925). Various physico–chemical and biological factors have been identified as being of primary importance in determining the distribution of peritrichs. These include the concentration of organic pollution (BOD); food source; flow rate; substrate preference, and relationships with predators and parasites.

The ability of different species of *Vorticella* to tolerate different levels of organic pollution was used by Kolkwitz & Marsson (1909) to form the basis of the first saprobic system for measuring water quality. Originally four saprobic zones were designated according to the species of *Vorticella* which predominate in each. More recently Sládećek (1971) defined the saprobic sequence of thirty-two species of *Vorticella*.

Of the other ecological factors food source (Curds & Vandyke, 1966), flow rate (Zimmerman, 1961), substrate preference (Sládečková, 1962) and relationships with predators and parasites (Noland, 1925; Spoon, 1975) may all provide useful information to aid species diagnoses although in most cases these have yet to be studied in sufficient detail. Taken alone these factors would be a very insecure criteria of species but they may serve to reinforce other more distinctive features.

Key to Species

Eighty-two species of *Vorticella* are recognised and may be identified with the aid of the following key. The morphological and behavioural characters used refer to those observed in healthy, freshly mounted specimens.

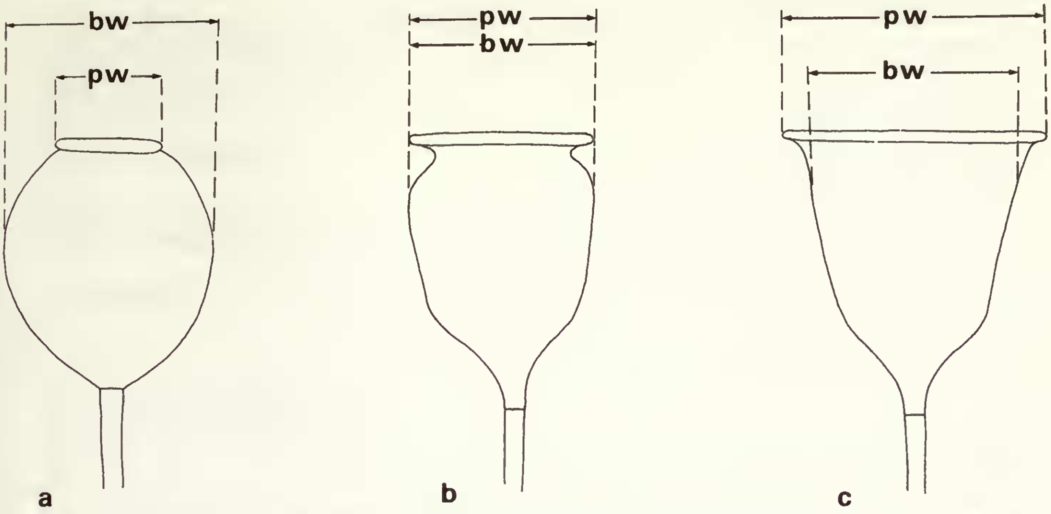

Fig. 3. Size of peristomial lip (PL) in relation to greatest body width (BW): (a) PL<BW; (b) PL=BW; (c) PL>BW.

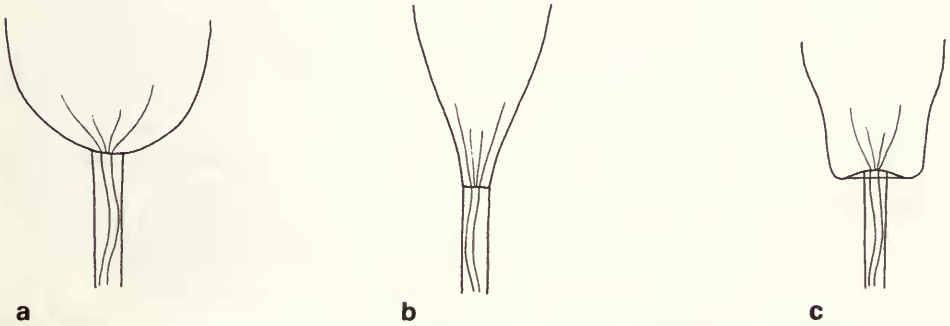

Fig. 4. Shape of scopular region of zoid: (a) rounded; (b) tapering; (c) truncated and overlapping.

1	Pellicle striated	2
–	Pellicle unstriated	61
2	Free-swimming and never attached to a substratum	3
–	Sessile, attached to substratum by its stalk	4
3	When swimming, stalk is held projecting forwards	***V. natans*** (Fig. 32c)
–	When swimming, stalk is used as a giant whip-like flagellum	***V. mayeri*** (Fig. 30)
4	Zooid does not contain endosymbiotic zoochlorellae	5
–	Zooid contains endosymbiotic zoochlorellae	***V. chlorostigma*** (Fig. 12b)
5	Spasmoneme has red or green thecoplasmic granules	6
–	When present, thecoplasmic granules are colourless	7

6 Zooid small, approximately 20 μm long × 10 μm wide, with a single c.v. and red thecoplasmic granules . . . . ***V. microscopica*** (Fig. 29b)

– Zooid approximately 58 μm long × 32 μm wide and with 2 c.v.'s; thecoplasmic granules red or green . . . . ***V. picta*** (Fig. 36a)

7 Zooid very long measuring 170–200 μm in length 8

– Zooid less than 170 μm long 9

8 Zooid elongate, cylindrical in shape and with two constrictions one centrally located and one beneath the peristome . . . . ***V. quadrangularis*** (Fig. 39b)

– Zooid trumpet-shaped, not constricted beneath the peristome and without a centrally located constriction . . . . ***V. kenti*** (Fig. 22b)

9 Stalk less than × 10 zooid length 10

– Stalk length × 10– × 20 zooid length . . . . ***V. macrostyla*** (Fig. 28a)

10 Zooid without ridges; contraction normal 11

– Two distinct ridges are present on lower half of zooid; upon contraction the area of zooid around each overlaps that below (see Fig. 44b) . . . . ***V. telescopoides*** (Fig. 44c)

11 Macronucleus lies horizontal with respect to major body axis and is usually C-shape 12

– Macronucleus lies longitudinally with respect to major body axis and is J-, C-, or irregular in shape 34

12 Upon contraction, peristomial lip folds inwards 13

– Upon contraction, peristomial lip is drawn up in the form of a narrow cylinder . . . . ***V. lymnaearum*** (Fig. 27a)

13 Pellicle has convex ribbing between striations (see Fig. 2) 14

– Pellicle has normal or concave ribbing between striations (Fig. 2) 20

14 Diameter of peristomial lip less than maximum body width (see Fig. 3) 15

– Diameter of peristomial lip equal to or greater than maximum body width 16

15 C.V. centrally located in zooid; infundibulum reaches $\frac{3}{4}$ zooid length . ***V. pulchella*** (Fig. 38a)

– C.V. situated just below peristome; infundibulum reaches one-third zooid length . . . . ***V. striata*** (Fig. 42a & b)

16 Zooid constricted beneath peristomial lip; pellicle has fine, narrow striations 17

– Zooid not constricted beneath peristomial lip; pellicle has distinct, broadly spaced striations . 19

17 Disc flat and slightly elevated above peristomial lip which is not significantly thickened . . 18

– Disc prominently arched and elevated high above peristomial lip which is significantly thickened . . . . ***V. incisa*** (Fig. 21a)

18 Diameter of peristomial lip equal to maximum body width . . . ***V. marina*** (Fig. 29a)

– Diameter of peristomial lip greater than maximum body width . . ***V. longiseta*** (Fig. 25b)

19 Zooid elongate, almost cylindrical in shape; diameter of peristomial lip equal to maximum body width (see Fig. 3) . . . . ***V. macrophya*** (Fig. 27b)

– Zooid trumpet-shaped; diameter of peristomial lip greater than maximum body width . . . . ***V. bidulphae*** (Fig. 9a)

20 Pellicle has concave ribbing between striations 21

– Pellicle has normal ribbing between striations (Fig. 2) 26

21 Diameter of peristomial lip equal to maximum body width 22

– Diameter of peristomial lip less than maximum body width 23

22 Stalk sheath twisted . . . . ***V. limnetis*** (Fig. 24b)

– Stalk sheath not twisted . . . . ***V. platysoma*** (Fig. 36b)

23 Macronucleus curved less than 360° 24

– Macronucleus curved more than 360° in a ring-like manner . ***V. operculariformis*** (Fig. 34a)

24 Pellicular pores sparse, usually 15 or 16 per 100 μm^2 on zooid surface 25

– Pellicular pores numerous with 70–120 (mean 104) per 100 μm^2 on zooid surface . . . . ***V. astyliformis*** (Fig. 8a & b)

25 Zooid has total of 18–30 (mean 21) striations on pellicle . . . ***V. costata*** (Fig. 14a & b)

– Zooid has total of 34–51 (mean 42) striations on pellicle . . ***V. infusionum*** (Fig. 21b & c)

26 Zooid has one c.v. 27

– Zooid has two c.v.'s . . . . ***V. dimorpha*** (Fig. 14c)

27 Diameter of peristomial lip less than × 2 maximum body width 28
– Diameter of peristomial lip at least × 2 maximum body width . . ***V. marginata*** (Fig. 28b)

28 Scopular region of zooid rounded or tapering but peripheral areas do not overlap stalk (Fig. 4a & b) 29
– Scopular region of zooid not rounded or tapering; peripheral areas overlap stalk (Fig. 4c) . . . . ***V. latifunda*** (Fig. 23a)

29 Diameter of peristomial lip less than maximum body width 30
– Diameter of peristomial lip equal to or greater than maximum body width. 31

30 Zooid 60–70 μm long; stalk × 3– × 5 zooid length . . . . . ***V. turgicula*** (Fig. 45a)
– Zooid 25–40 μm long; stalk less than ½ zooid length . . . . . ***V. bosminae*** (Fig. 10a)

31 Zooid held vertically on stalk and not noticeably curved 32
– Zooid curved and held at an angle to stalk . . . . ***V. hamata*** (Fig. 20b)

32 Zooid elongate, length approximately × 2– × 3 maximum body width 33
– Zooid inverted bell-shaped; length approximately equal to maximum body width . . . . ***V. campanulata*** (Fig. 12a)

33 Zooid approximately 90 μm long; an oblique ridge is present on lower one-third of body . . . . ***V. fromenteli*** (Fig. 17a)
– Zooid approximately 40 μm long and without an oblique ridge . . . ***V. parasita*** (Fig. 35a)

34 Macronucleus C-shaped 35
– Macronucleus irregular or J-shaped 48

35 Pellicle has convex ribbing between striations 36
– Pellicle has normal or concave ribbing 37

36 Upon contraction, peristomial lip becomes puckered (see Fig. 43b) ***V. szczepanowskii*** (Fig. 43c)
– Upon contraction, peristomial lip is drawn up in the shape of a narrow cylinder. ***V. venusta*** (Fig. 45b & c)

37 Tubercles or granules present on pellicle 38
– Pellicle without tubercles or granules 39

38 Zooid has two c.v.'s. . . . . ***V. vernalis*** (Fig. 46a)
– Zooid has one c.v. . . . . ***V. granulata*** (Fig. 19c)

39 Pellicle has concave ribbing between striations 40
– Pellicle has normal ribbing 42

40 Zooid held erect on stalk 41
– Zooid held at an angle with respect to stalk . . . . ***V. lima*** (Fig. 24a)

41 Zooid has a total of 38–70 (mean 58) pellicular striations . . . . ***V. aequilata*** (Fig. 5a)
– Zooid has 65–89 (mean 72) pellicular striations. . . . . . ***V. alpestris*** (Fig. 6a & b)

42 Diameter of peristomial lip less than maximum body width 43
– Diameter of peristomial lip greater than or equal to maximum body width. 44

43 Disc prominently arched above peristome; stalk has constriction ½ way down below which it is non-contractile . . . . ***V. lichenicola*** (Fig. 23b)
– Disc flat or slightly convex; stalk without constriction and contracts normally . . . . ***V. microstoma*** (Fig. 31)

44 Zooid held erect on stalk 45
– Zooid curved and held at an angle with respect to stalk . . ***V. subprocumbens*** (Fig. 42c)

45 Macronucleus short, length approximately × 5 width 46
– Macronucleus elongate, length greater than × 5 width 47

46 Diameter of peristomial lip equal to maximum body width . . . ***V. exilis*** (Fig. 16a)
– Diameter of peristomial lip greater than maximum body width . . ***V. longitricha*** (Fig. 26a)

47 Peristomial lip has several spine-like projections; stalk sheath not twisted . ***V. pulchra*** (Fig. 38b)
– Peristomial lip without spine-like projections; stalk sheath twisted . ***V. flexuosa*** (Fig. 16b & c)

48 Macronucleus irregular in shape; proximal region lies longitudinally with respect to major axis of zooid 49
– Macronucleus J-shaped; proximal region lies horizontally across peristome 50

49 Zooid elongate with prominent bulge in lower one-third; diameter of peristomial lip less than maximum body width . . . ***V. muralis*** (Fig. 32a & b)
– Zooid inverted bell-shaped; diameter of peristomial lip equal to or greater than maximum body width . . . ***V. jaerae*** (Fig. 22a)

50 Upon contraction buccal cilia are withdrawn into peristome which closes completely . . . 51
– Upon contraction cilia are not withdrawn and peristome only partially closes . . . ***V. elongata*** (Fig. 15b & c)

51 Pellicle has convex ribbing between striations . . . 52
– Pellicle has normal or concave ribbing . . . 53

52 Zooid has two c.v.'s . . . ***V. halophila*** (Fig. 20a)
– Zooid has one c.v. . . . ***V. lutea*** (Fig. 26b)

53 Zooid with either a membranous or mucilagenous covering . . . 54
– Zooid without a membranous or mucilagenous covering . . . 55

54 Zooid with membranous, alveolar investment . . . ***V. vestita*** (Fig. 47a)
– Zooid with mucilagenous covering . . . ***V. rhabdophora*** (Fig. 40a)

55 Diameter of peristomial lip greater than zooid length . . . 56
– Diameter of peristomial lip less than zooid length . . . 57

56 Peristomial lip with undulating, frill-like rim; cytoplasm without dark, refractile inclusions . . . ***V. cratera*** (Fig. 15a)
– Peristomial lip without frill-like rim; cytoplasm contains numerous dark, refractile inclusions . . . ***V. campanula*** (Fig. 11)

57 Pellicle has concave ribbing between striations . . . 58
– Pellicle has normal ribbing between striations . . . 59

58 Diameter of peristomial lip less than maximum body width . . . ***V. sepulcreti*** (Fig. 41b)
– Diameter of peristomial lip equal to or greater than maximum body width . . . ***V. gracilis*** (Fig. 19a & b)

59 C.V. situated in upper one-third of zooid . . . 60
– C.V. centrally located in zooid . . . ***V. banatica*** (Fig. 8c)

60 Diameter of peristomial lip less than or equal to maximum body width; zooid elongate . . . ***V. calciformis*** (Fig. 10b)
– Diameter of peristomial lip greater than maximum body width; zooid inverted bell-shaped . . . ***V. convallaria*** (Fig. 13b & c)

61 Diameter of peristomial lip less than maximum body width . . . 62
– Diameter of peristomial lip equal to or greater than maximum body width . . . 67

62 Pellicle without spine-like projections . . . 63
– Pellicle with numerous spine-like projections . . . ***V. voeltzkowi*** (Fig. 47b)

63 Zooid almost spherical in shape, body length about equal to maximum body width . . . 64
– Zooid not spherical; body length greater than maximum body width . . . 65

64 Stalk with one or more distinct annulations; usually solitary and not forming pseudocolonies . . . ***V. anomala*** (Fig. 7a)
– Stalk without annulations; typically forms pseudocolonies . . . ***V. globularia*** (Fig. 18b)

65 Zooid with one c.v. . . . 66
– Zooid with two c.v.'s . . . ***V. bivacuolata*** (Fig. 9b)

66 Diameter of peristomial lip usually greater than ½ maximum body width; stalk length about equal to length of zooid . . . ***V. ovum*** (Fig. 34b)
– Diameter of peristomial lip about ½ maximum body width; stalk up to × 4– × 5 zooid length . . . ***V. globosa*** (Fig. 18a)

67 Stalk without annulations . . . 68
– Stalk with 1–3 distinct annulations . . . ***V. annulata*** (Fig. 6c)

68 Zooid without extracellular membranous investment . . . 69
– Zooid with extracellular membranous investment . . . ***V. aperta*** (Fig. 7b)

69 Pellicle without tubercles . . . 70
– Pellicle with numerous irregular tubercles . . . ***V. verrucosa*** (Fig. 46b)

70 Zooid without a distinct ridge in region of telotroch band . . . 71
– Zooid with a distinct ridge in region of telotroch band . . . ***V. obconica*** (Fig. 33b)

71	Macronucleus lies horizontal with respect to major axis of zooid	72
–	Macronucleus lies vertical with respect to major axis of zooid	74
72	Scopular region of zooid tapers towards stalk (see Fig. 4)	73
–	Scopular region of zooid rounded and does not taper towards stalk	***V. communis*** (Fig. 13a)
73	Diameter of peristomial lip greater than maximum body width	***V. pyriforme*** (Fig. 39a)
–	Diameter of peristomial lip less than or equal to maximum body width	***V. rotunda*** (Fig. 40b)
74	Macronucleus J-shaped	75
–	Macronucleus straight, irregular or C-shaped	77
75	When present, thecoplasmic granules colourless	76
–	Thecoplasmic granules red	***V. rubristigma*** (Fig. 41a)
76	Zooid 68–85 µm long; macronucleus typically long and thin	***V. poznaniensis*** (Fig .37)
–	Zooid 88–100 µm long; width of macronucleus normal	***V. fusca*** (Fig. 17b)
77	Zooid without distinct pellicular ridges; contraction normal	80
–	Two parallel transverse ridges are present on lower ½ of zooid; upon contraction, the area of zooid above each overlaps that below (see Fig. 44b)	***V. telescopica*** (Fig. 44a)
78	Diameter of peristomial lip less than zooid length	79
–	Diameter of peristomial lip equal to or greater than zooid length	***V. patellina*** (Fig. 35b)
79	Zooid held in vertical position with respect to stalk	80
–	Zooid held in characteristic nodding position	***V. nutans*** (Fig. 33a)
80	Macronucleus short, length approximately ×5–×6 width, and slightly curved; stalk less than ×5 zooid length	81
–	Macronucleus elongate, length approximately ×15 width, with both ends sharply curved; stalk approximately ×10 zooid length	***V. longifilum*** (Fig. 25a)
81	Disc prominently arched above peristome; infundibulum reaches two-thirds zooid length	***V. subsinuata*** (Fig. 43a)
–	Disc flat; infundibulum short, terminating in upper one-third of zooid	***V. alba*** (Fig. 5b)

Species descriptions

The recognised species with their synonyms are given below.

V. aequilata Kahl, 1939

DIAGNOSIS (Fig. 5a): zooid 40–50 µm long × 20 µm wide, peristomial lip 15 µm in diameter; peristomial region constricted giving zooid the appearance of a somewhat elongated barrel; peristomial disc bulges prominently above lip; pellicle clearly striated; macronucleus C-shaped and situated longitudinally along the axis of the body; one c.v. situated near the cytopharynx; stalk up to 200 µm long.

HABITAT. Freshwater and marine.

REMARKS. For biometric analysis see Reid (1967).

V. alba Fromentel, 1874

DIAGNOSIS (Fig. 5b). Zooid 60–80 µm long × 25 µm wide, inverted bell-shaped and constricted below peristomial lip which measures 25 µm across; disc convex; infundibulum reaches one-third body length; C.V. situated in upper one-third of zooid; macronucleus C-shaped and lies longitudinally in centre of body; pellicular striations not visible; stalk 180–300 µm long.

HABITAT. Freshwater, solitary.

V. alpestris Foissner, 1979

DIAGNOSIS (Figs 6a & b). Zooid 35–45 µm long × 20 µm wide; body constricted beneath peristomial lip which measures 20 µm across; infundibulum nearly reaches centre of zooid; C.V. lies just above centre of body and empties into ventral wall of infundibulum; macronucleus J-shaped and situated longitudinally with respect to major axis of zooid; pellicle distinctly striated with concave ribbing between striations.

HABITAT. Freshwater.

REMARKS: Foissner's (1979) original description includes a biometric analysis.

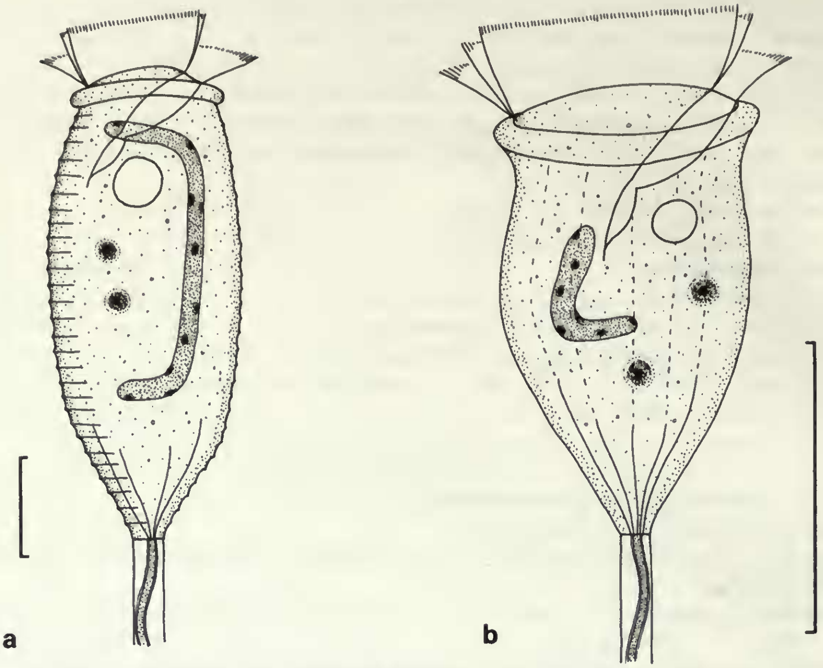

Fig. 5. (a) *V. aequilata* (after Kahl, 1935) bar = 10 µm; (b) *V. alba* (after Curds, 1969), bar = 50 µm.

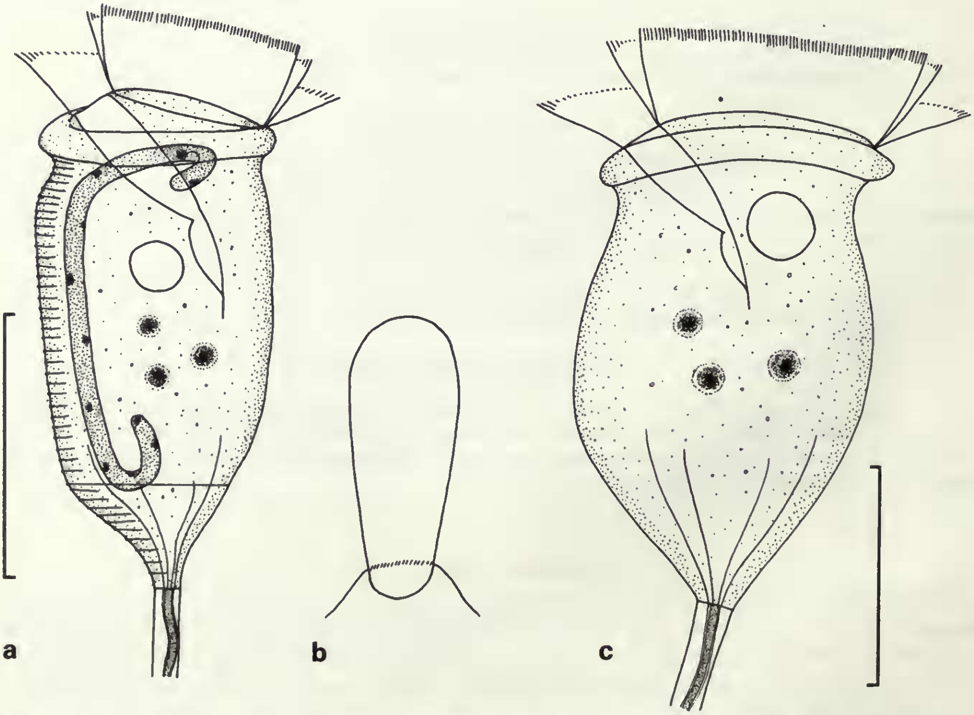

Fig. 6. (a) *V. alpestris* zooid, bar = 25 µm; (b) telotroch (after Foissner, 1979), bar = 10 µm; (c) *V. annulata* (after Gourret & Roeser, 1888), bar = 25 µm.

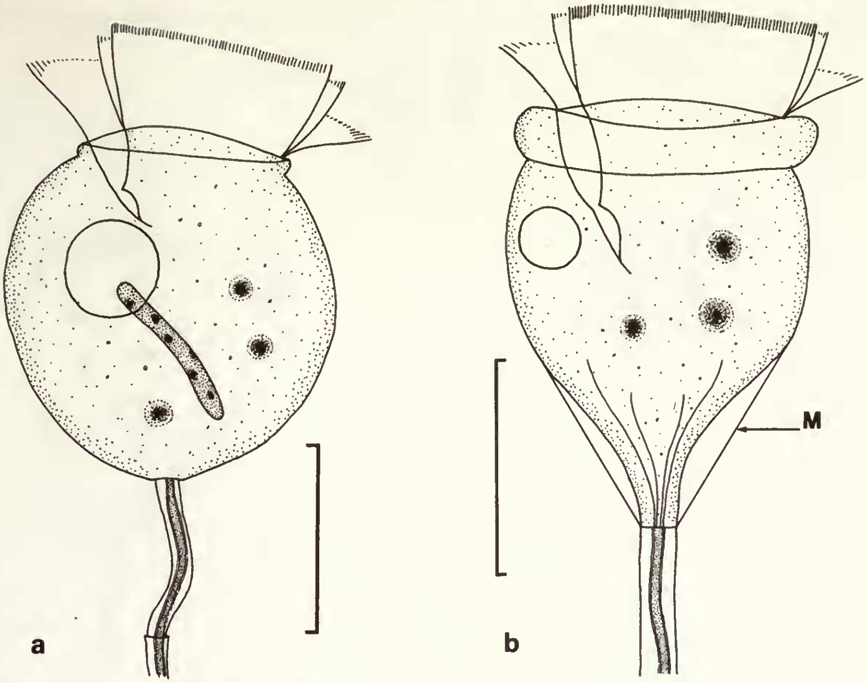

Fig. 7. (a) *V. anomala* (after Gourret & Roeser, 1886), bar = 25 μm; (b) *V. aperta* (after Fromentel, 1874), bar = 25 μm, M = membrane.

V. annulata (Gourret & Roeser, 1888) Kahl, 1935

V. brevistyla var. *annulata* Gourret & Roeser, 1888

Diagnosis (Fig. 6c). Zooid 55 μm long × 35 μm wide, inverted bell-shaped with constriction beneath peristomial lip which measures 35 μm across; C.V. situated just below peristome; stalk up to 200 μm long with two or more distinct annulations.

Habitat. Marine.

V. anomala Gourett & Roeser, 1886

Diagnosis (Fig. 7a). Zooid spherical in shape, 40 μm in diameter; disc prominently arched above narrow peristomial lip; macronucleus short and straight and lies obliquely across lower part of body; C.V. centrally located; pellicular striations not visible; approximately half-way down stalk is a ridge below which the stalk is wider and non-contractile.

Habitat. Marine, solitary

V. aperta Fromentel, 1874

Diagnosis (Fig. 7b). Zooid 60 μm long × 45 μm wide, inverted bell-shaped and constricted below peristomial lip which measures 45 μm across; disc flat or slightly concave; infundibulum short; C.V. situated just below peristome; pellicular striations not visible; entire zooid covered by a smooth membranous layer which is most easily seen in lower region; stalk up to 200 μm long.

Habitat. Freshwater.

V. astyliformis Foissner, 1981

Diagnosis (Fig. 8a & b). Zooid 30–50 μm long × 35–45 μm wide, nearly spherical in shape with a narrow peristomial lip which measures 20 μm across; infundibulum reaches centre of zooid; C.V. situated just below

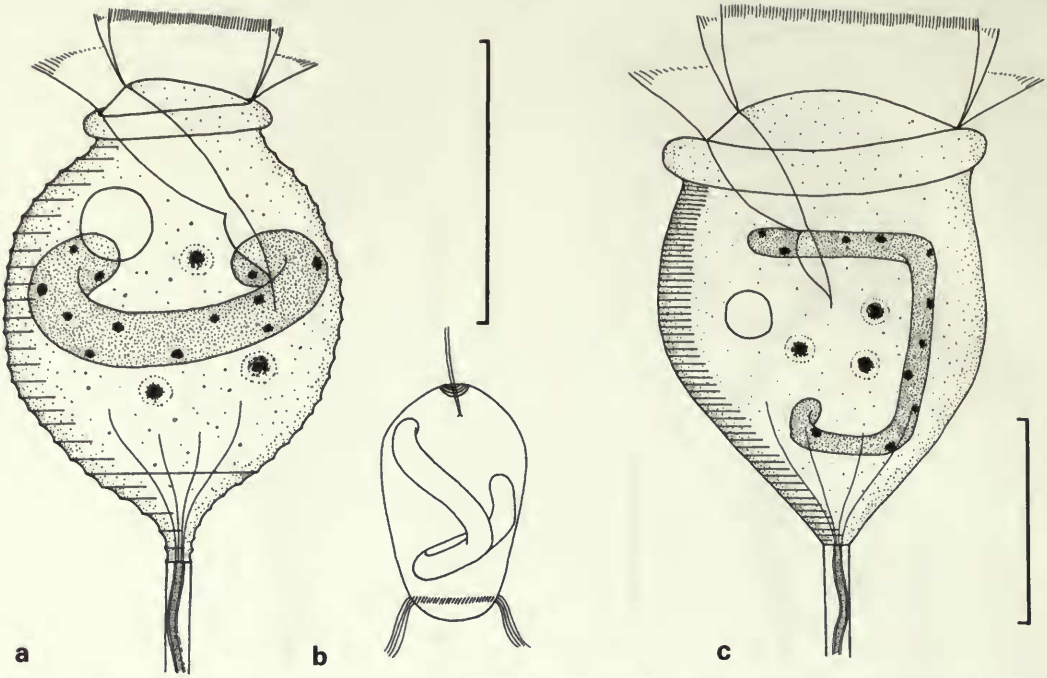

Fig. 8. (a) *V. astyliformis* zooid; (b) telotroch (after Foissner, 1981), bar = 25 µm; (c) *V. banatica* (after Stiller, 1971), bar = 25 µm

peristome and empties into left hand wall of infundibulum; macronucleus C-shaped and lies horizontal to the major axis of the zooid; pellicle clearly striated and has concave ribbing between striations; telotroch is slender with a prominent epistomial membrane.

HABITAT. Freshwater, originally isolated from Alpine soils.

V. banatica Lepsi

DIAGNOSIS (Fig. 8c). Zooid 60–80 µm long × 50 µm wide, inverted bell-shaped with a well developed peristomial lip which measures 55 µm across; disc prominently arched above peristome; infundibulum reaches one-third body length; C.V. situated just above centre of zooid; macronucleus long and J-shaped with upper arm lying across peristome; pellicle finely striated; stalk slender and up to 80 µm long.

REMARKS. Drawing and description from Stiller (1971).

V. bidulphae Stiller, 1939

V. variabilis Stiller, 1939.

DIAGNOSIS (Fig. 9a). Zooid 40 µm long × 20 µm wide, triangular in shape with a broad peristomial lip measuring 35–45 µm across; disc flat or slightly convex; infundibulum reaches centre of zooid; C.V. situated in upper one-third of body and empties into right hand wall of infundibulum via a short channel; macronucleus C-shaped and lies transversely across centre of zooid; pellicle distinctly striated with convex ribbing between the striations; stalk up to 120 µm long; cysts measure 32 µm in diameter.

HABITAT. Marine, originally isolated from the North Sea attached to *Bidulphae chinensis*.

V. bivacuolata Fukui & Morishita, 1961

DIAGNOSIS (Fig. 9b). Zooid 95–120 µm long × 55–68 µm wide, barrel-shaped and constricted below well developed peristomial lip which measures 60 µm across; disc prominently arched above peristome;

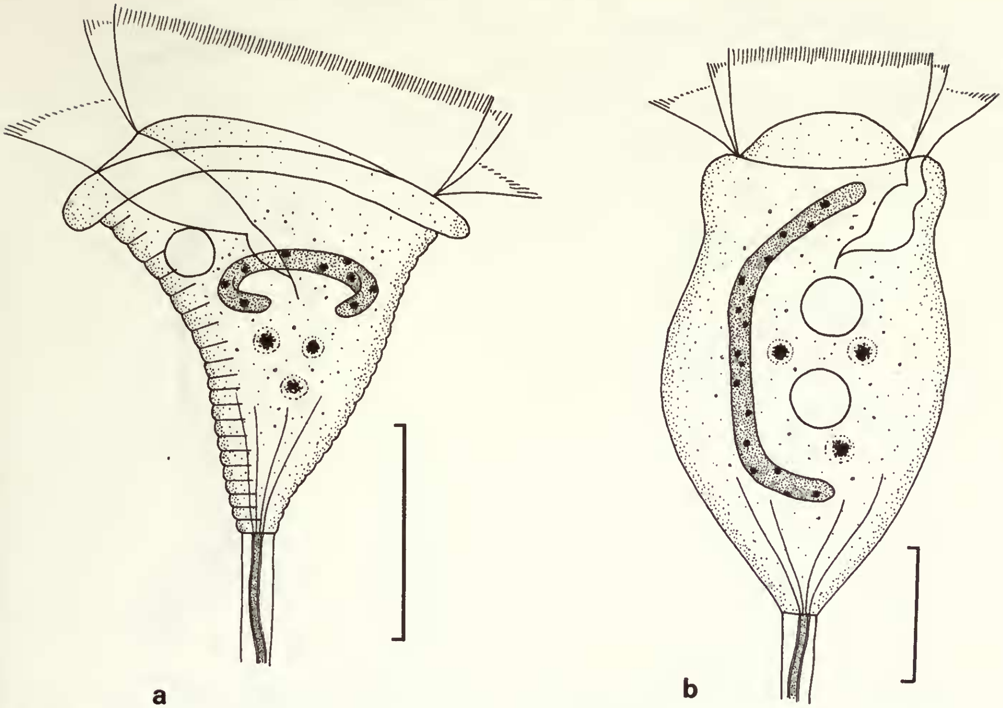

Fig. 9. (a) *V. bidulphae* (after Stiller, 1939), bar = 25 µm; (b) *V. bivacuolata* (after Fukui & Morishita, 1961), bar = 25 µm.

infundibulum short; two C.V.'s centrally located in body; macronucleus long, C-shaped and lies longitudinally with respect to major axis of body; pellicular striations not visible; stalk 3·0–4·0 µm wide.

HABITAT. Freshwater, originally isolated from activated sludge.

V. bosminae Šramek-Hušek, 1948

DIAGNOSIS (Fig. 10a). Zooid 25–40 µm long × 20–30 µm wide, somewhat rotund and constricted below peristomial lip which measures 15–20 µm across; C.V. situated just below peristome; macronucleus C-shaped and lies transversely across centre of body; pellicle distinctly striated; stalk up to 20 µm long.

HABITAT. Freshwater, originally isolated from pond water as an epizooite attached to the crustaceans, *Bosmina longirostris, Thermocyclopsis hyalinus, Mesocyclopsis leukarti* and *M. viridis*.

V. calciformis Kahl, 1933

DIAGNOSIS (Fig. 10b). Zooid 90 µm long × 65 µm wide, constricted below peristomial lip which measures 65 µm across; disc flat and obliquely elevated above peristome; C.V. small and situated just below peristome; macronucleus long and J-shaped lying longitudinally with respect to major axis of body; pellicle distinctly striated.

HABITAT. Marine

V. campanula Ehrenberg, 1831

V. campanula f. *minor* Stiller, 1953
V. campanula f. *citrina* var. *minor* Stiller, 1953
V. cylindrica Dons, 1915
V. dilatata (Fromentel, 1874), Noland & Finley, 1931
V. lunaris (Muller, 1773) Noland & Finley, 1931

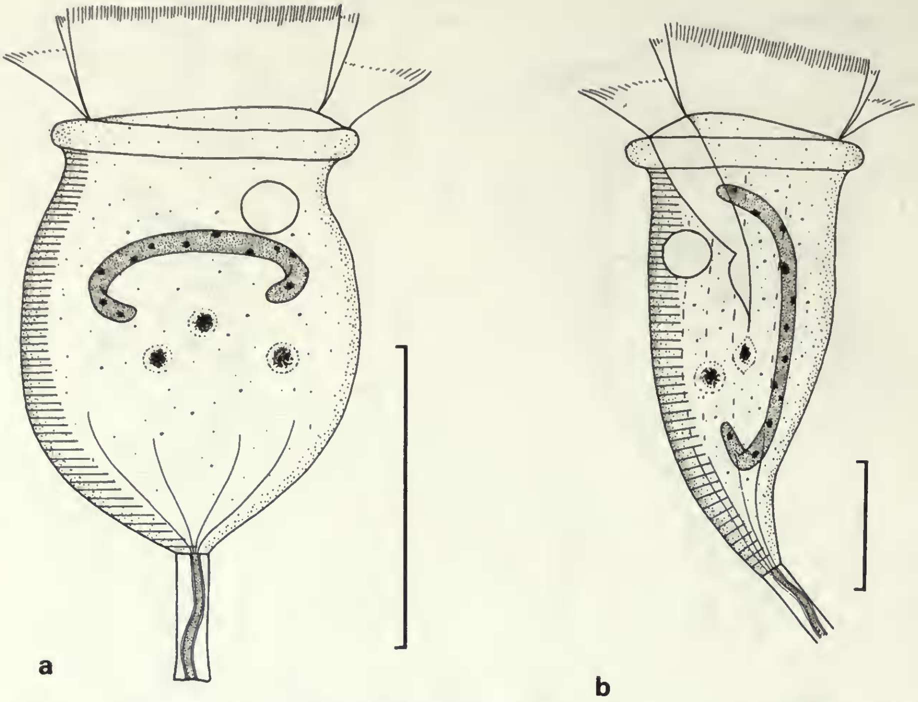

Fig. 10. (a) *V. bosminae* (after Šramek-Hušek, 1948), bar = 25 μm; (b) *V. calciformis* (after Kahl, 1935), bar = 25 μm.

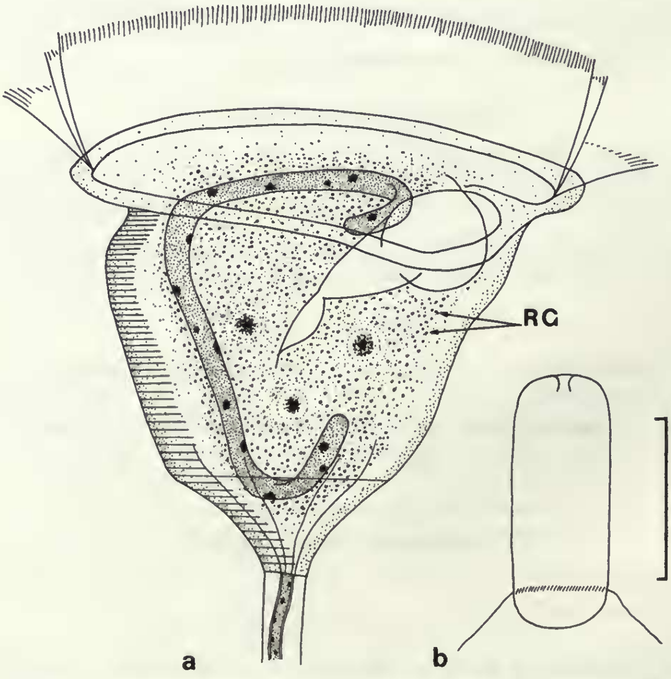

Fig. 11. *V. campanula* (a) zooid; (b) telotroch (after Noland & Finley, 1931), bar = 25 μm.

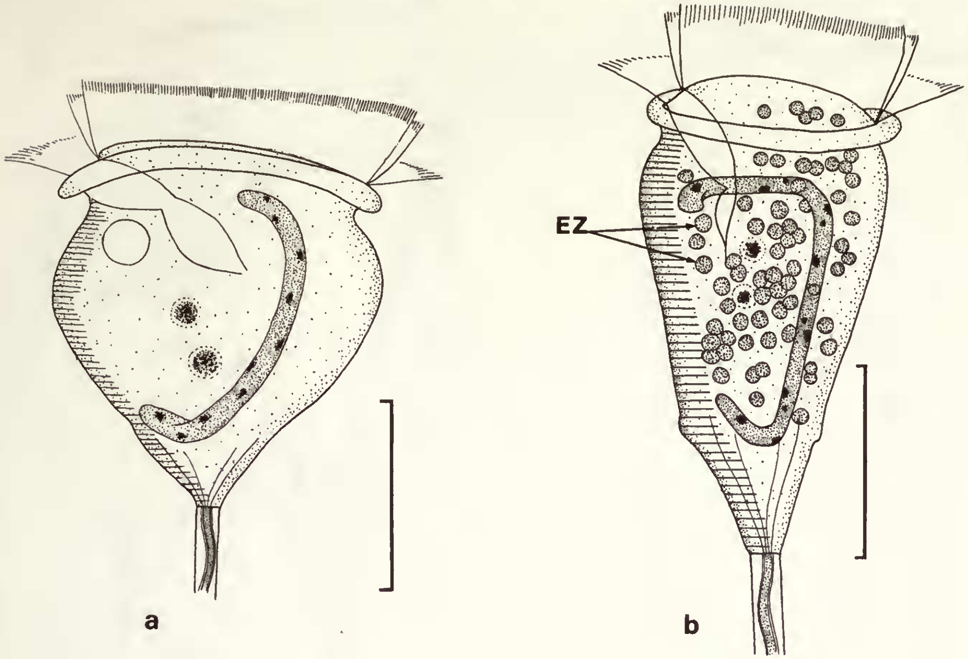

Fig. 12. (a) *V. campanulata* (after Šramek-Hušek, 1948), bar = 25 µm; (b) *V. chlorostigma* (after Stiller, 1941), bar = 25 µm.

V. macrostoma Schmarda, 1854
V. margaritifera (Fromentel, 1874) Noland & Finley, 1931
V. patellina (Ehrenberg, 1831) Noland & Finley, 1931

Diagnosis (Figs 11a & b). Zooid 50–157 µm long (mean 68 µm) × 35–99 µm wide (mean 58 µm); inverted bell-shaped and constricted below peristomial lip which measures 60–125 µm across (mean 78 µm); upon contraction, peristomial lip becomes puckered; disc flat and obliquely elevated above peristome; infundibulum broad; C.V. situated in upper one-third of zooid; macronucleus long, J-shaped and situated longitudinally in body with upper arm lying horizontally across peristome; cytoplasm contains numerous dark, refractile granules; pellicle finely striated; stalk up to 500 µm long and spasmoneme has numerous thecoplasmic granules.

Habitat. Freshwater or marine; often forms large pseudocolonies; occasionally epibiotic on various aquatic arthropods (Green, 1974).

Remarks. For biometric analysis, see Foissner & Schiffmann (1974).

V. campanulata (Kahl, 1933) Šramek-Hušek, 1948

V. constricta Kahl, 1933

Diagnosis (Fig. 12a). Zooid 45 µm long × 50 µm wide and constricted beneath peristomial lip which measures 50 µm across; disc flat; infundibulum reaches one-third zooid length; c.v. situated just beneath peristome; macronucleus C-shaped and situated longitudinally in zooid; pellicle striated.

Habitat. Freshwater or marine.

Remarks. Šramek-Hušek (1948*b*) isolated a vorticellid from the River Vltave, Prague which he identified as *V. constricta* Kahl, 1933. It was renamed *V. campanulata* in order to solve the problem of homonymy with Fromentel's (1874) *V. constricta*.

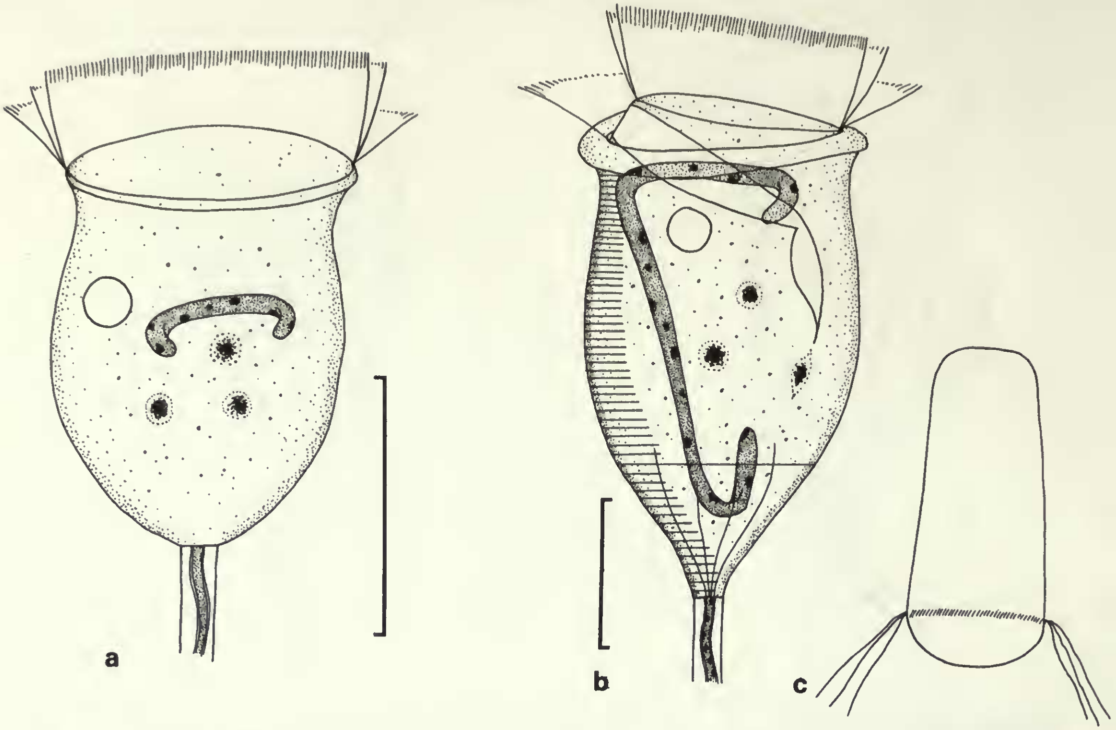

Fig. 13. (a) *V. communis* (after Curds, 1969), bar = 25 μm; (b) *V. convallaria* zooid; (c) telotroch (after Foissner, 1979), bar = 25 μm.

V. chlorostigma Ehrenberg, 1831

V. chlorellata Stiller, 1940

Diagnosis (Fig. 12b). Zooid 55–60 μm long × 25–30 μm wide, almost conical in shape, sometimes with a distinct ridge near the telotroch band and sharply constricted below peristomial lip which measures 30–35 μm across; disc flat and slightly elevated above peristome; infundibulum reaches $\frac{1}{4}$ body length; C.V. situated in upper one-third of body and empties into left hand wall of infundibulum; macronucleus C-shaped and situated longitudinally in zooid; cytoplasm contains numerous endosymbiotic zoochlorellae; pellicle finely striated; stalk up to 600 μm long.

Habitat. Freshwater lakes.

Remarks. An ultrastructural study of the association between *Vorticella* and its endosymbiotic zoochlorellae was made by Graham & Graham (1980).

V. communis Fromentel, 1874

V. subsphaerica Dons 1915

Diagnosis (Fig. 13a). Zooid 30 μm long × 25 μm wide, somewhat rotund and slightly constricted beneath peristomial lip which measures 25 μm in diameter; disc flat; c.v. situated in upper one-third of body; macronucleus C-shaped and lies transversely across centre of zooid; pellicular striations not visible.

Habitat. Freshwater or marine; solitary.

V. convallaria Linnaeus, 1758

V. chinensis Tai, 1931
V. citrina (Müller, 1773) Fauré-Fremiet, 1904

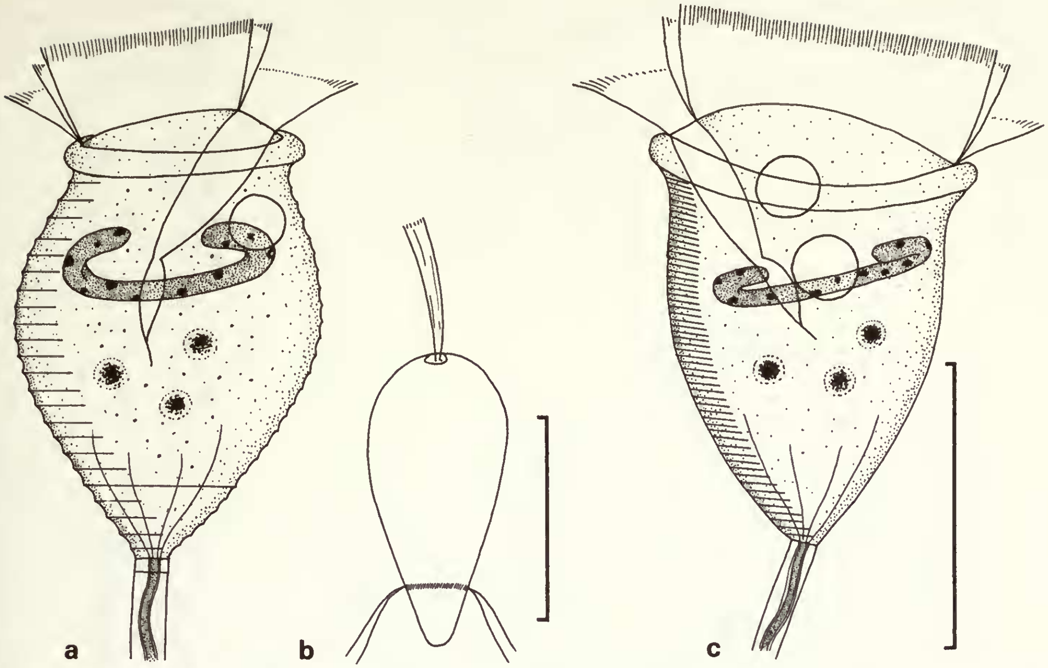

Fig. 14. (a) *V. costata* zooid; (b) telotroch (after Foissner, 1979), bar = 10 µm; (c) *V. dimorpha* (after Stiller, 1940), bar = 25 µm.

V. citrina var. *turgescens* Stiller, 1931
V. convallaria var. *compacta* Nenninger, 1948
V. cothurnata (Hemprich & Ehrenberg, 1828) Ehrenberg, 1838
V. cyathina (Müller) Ehrenberg, 1838
V. cyclopis Kahl, 1933
V. hyalina Stiller, 1940
V. nebulifera var. *similis* (Noland & Finley, 1931) Reid, 1967
V. similis (Stokes, 1887), Reid, 1967

Diagnosis (Figs 13b & c). Zooid 50–95 µm long (mean 77 µm) × 35–55 µm wide (mean 44 µm), inverted bell-shaped and constricted beneath peristomial lip which measures 55–75 µm across (mean 65 µm); disc flat or slightly convex and obliquely elevated; infundibulum reaches one-third body length; C.V. situated in upper one-third of zooid; macronucleus long and J-shaped with upper arm lying horizontally across peristome: pellicle distinctly striated; stalk up to 460 µm long and spasmoneme has numerous thecoplasmic granules.

Habitat. Freshwater or marine; often forms pseudocolonies; occasionally epibiotic.

Remarks. For biometric analyses see Reid (1967) and Foissner (1979).

V. costata (Sommer, 1951) Foissner, 1979

V. octava f. *costata* Sommer, 1951

Diagnosis (Figs 14a & b). Zooid 20–28 µm long × 15–20 µm wide and constricted below peristomial lip which measures 15 µm across; disc convex; infundibulum extends to one-third body length; C.V. situated just below peristome and empties into ventral wall of infundibulum; macronucleus C-shaped and lies transversely across centre of zooid; pellicle has concave ribbing between distinct, widely spaced striations; stalk up to 150 µm long; telotroch pyriform with prominent epistomial membrane.

Habitat. Freshwater.

Remarks. For biometric analysis see Foissner (1979).

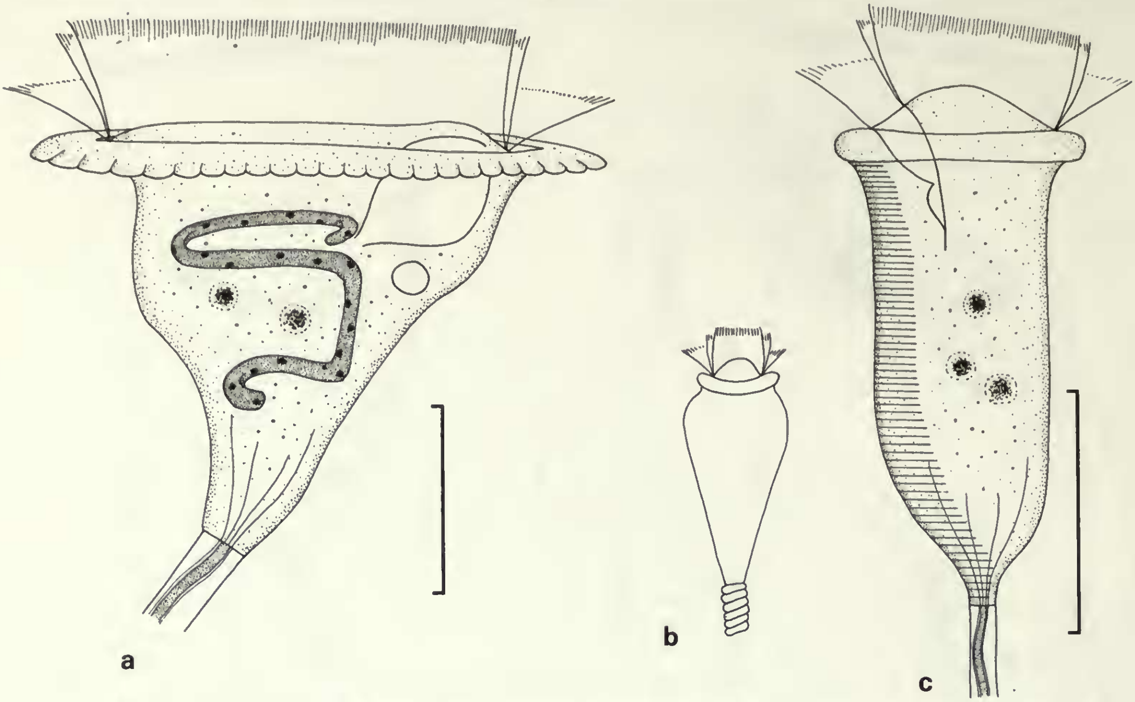

Fig. 15. (a) *V. cratera* (after Küsters, 1974), bar = 25 µm; (b) *V. elongata*, contracted zooid; (c) relaxed zooid (after Fromentel, 1874), bar = 25 µm.

V. cratera Kent, 1881

V. dudekemi Kahl, 1933

Diagnosis (Fig. 15a). Zooid 120 µm long × 100 µm wide, inverted bell-shaped with a broad, flat peristomial lip measuring 150 µm across which has an undulating, frill-like border; infundibulum short; C.V. situated in upper one-third of zooid close to infundibulum; macronucleus long and J-shaped with upper arm lying across peristome; pellicle finely striated; stalk up to 800 µm long.

Habitat. Freshwater or marine; often form pseudocolonies.

V. dimorpha Stiller, 1940

Diagnosis (Fig. 14c). Zooid 32–35 µm long × 15–20 µm wide, variable in shape but usually not constricted below peristomial lip which measures 25 µm across; disc prominently arched above peristome; infundibulum narrow, extending to one-third body length; two C.V.'s situated on either side of infundibulum, the right hand one lying deeper in the cytoplasm, pulses more slowly and is formed by the fusion of two or three smaller vacuoles; macronucleus long, thin, C-shaped and lies diagonally across centre of zooid; pellicle finely striated; stalk slender and up to 70 µm long.

Habitat. Freshwater, originally isolated as an epibiont on *Conchilus unicornis* from Lake Holstein.

V. elongata Fromentel, 1874

V. conica (Stokes, 1887) Noland & Finley, 1931
V. multangula (Fromentel, 1874) Noland & Finley, 1931
V. plicata (Gourret & Roeser, 1886) Noland & Finley, 1931
V. sybcylindrica Ghosh, 1922

Diagnosis (Figs 15b & c). Zooid 60 µm long × 30 µm wide, cylindrical in shape and not constricted beneath peristomial lip which measures 40–45 µm across; disc convex; infundibulum short and broad; pellicle finely striated; upon contraction, peristome only partially closes and cilia are not withdrawn (see Fig. 14c).

Habitat. Freshwater or marine.

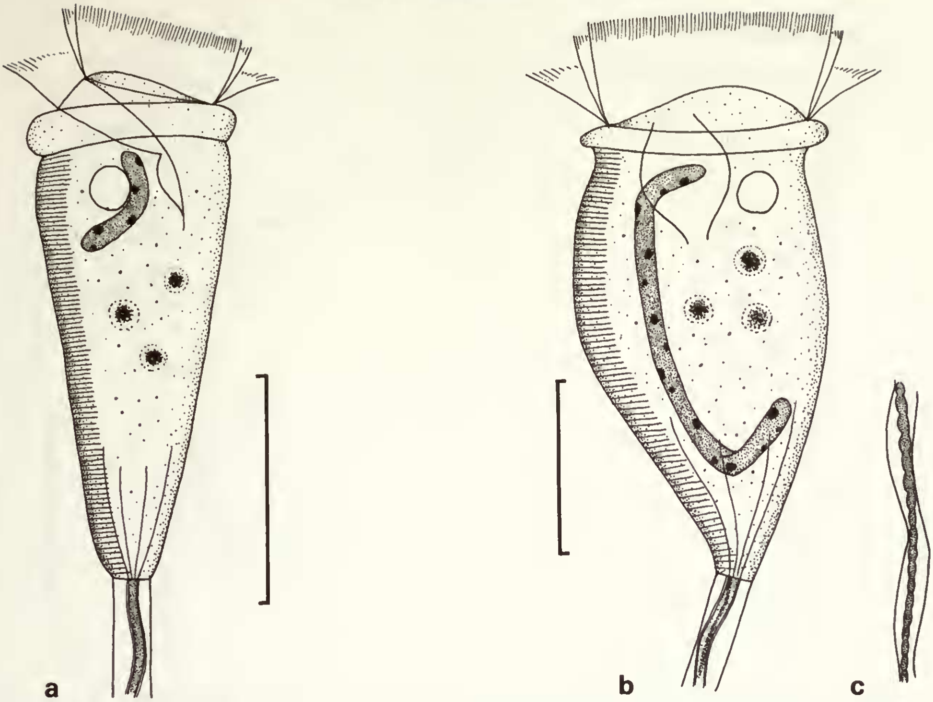

Fig. 16. (a) *V. exilis* (after Nenninger, 1948), bar = 25 µm; (b) *V. flexuosa* zooid, bar = 50 µm; (c) stalk (after Nenninger, 1948).

V. exilis Nenninger, 1948

DIAGNOSIS (Fig. 16a). Zooid 48–60 µm long × 15–20 µm wide, elongate and almost cylindrical in shape but slightly constricted beneath well developed peristomial lip which measures 20 µm across; disc flat and obliquely elevated above peristome; infundibulum short; C.V. lies in niche of macronucleus which is short, thick, slightly curved and situated in upper one-third of body; pellicle distinctly striated; stalk up to 350 µm long.

HABITAT. Freshwater, originally isolated as an epibiont on the crustacean *Lestes virus* and the mollusc *Lymnaea stagnalis*.

V. flexuosa Nenninger, 1948

DIAGNOSIS (Figs 16b & c). Zooid 126–144 µm long × 70 µm wide, inverted bell-shaped with slight constriction below peristomial lip which measures 75 µm across; disc prominently arched above peristome; infundibulum short and broad; macronucleus long, C-shaped and lies longitudinally with respect to major axis of body; pellicle finely striated; stalk up to 450 µm long and has a twisted sheath; spasmoneme has single row of thecoplasmic granules.

HABITAT. Freshwater, originally isolated as an epibiont on the crustacean *Asellus aquaticus* and *Ricciocarpus natans*.

V. fromenteli (Fromentel, 1874) Kahl, 1935

V. cucullus Fromentel, 1874

DIAGNOSIS (Fig. 17a). Zooid 90 µm long × 30 µm wide, elongated trumpet-shaped and not constricted below peristomial lip which measures 40 µm across; disc prominently arched; infundibulum narrow and reaches one-third of body length; C.V. situated just below peristome; macronucleus C-shaped and lies transversely

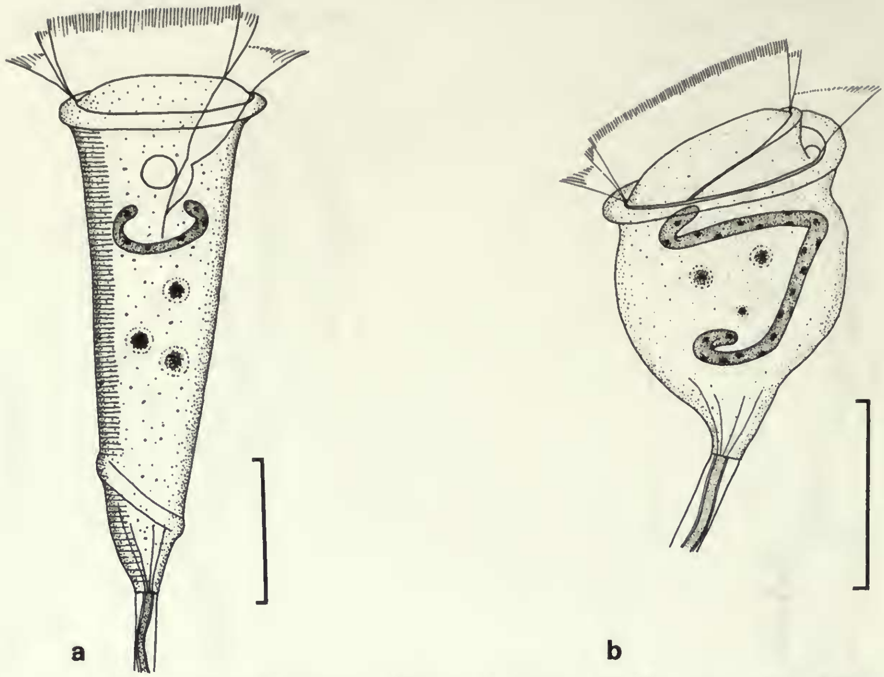

Fig. 17. (a) *V. fromenteli* (after Kahl, 1935), bar = 25 µm; (b) *V. fusca* (after Precht, 1935), bar = 25 µm.

in upper one-third of zooid; pellicle distinctly striated; a single obliquely orientated ridge is present in lower $\frac{1}{4}$ of zooid.

Habitat. Freshwater.

V. fusca Precht, 1935

Diagnosis (Fig. 17b). Zooid 88–110 µm long × 65–75 µm wide, inverted bell-shaped with constriction beneath peristome; peristomial lip measures 75 µm across; disc convex and prominently arched above peristome; macronucleus J-shaped; pellicular striations not observed; stalk up to 200 µm long and has numerous thecoplasmic granules.

Habitat. Marine, originally isolated from the Baltic Sea attached to *Enteromorpha*; typically forms pseudocolonies.

V. globosa Ghosh, 1922

V. urnula Nenninger, 1948

Diagnosis (Fig. 18a). Zooid 25–65 µm long × 20–45 µm wide, somewhat rotund and with a narrow peristomial lip which measures 10 µm across; disc narrow and convex; infundibulum broad and extends to centre of body; c.v. situated in upper part of zooid close to infundibulum; macronucleus C-shaped and lies transversely across centre of zooid; pellicular striations not visible; stalk up to 125 µm long.

Habitat. Freshwater, originally isolated from pond water near Bengal; occasionally epibiotic.

V. globularia Müller, 1773

V. salina Schmarda, 1854
V. sphaerica d'Udekem, 1864

Diagnosis (Fig. 18b). Zooid 160 µm long × 150 µm wide, spherical in shape with narrow peristomial lip; pellicular striations not visible; stalk up to 1000 µm long.

Habitat. Freshwater, forms pseudocolonies; occasionally epibiotic.

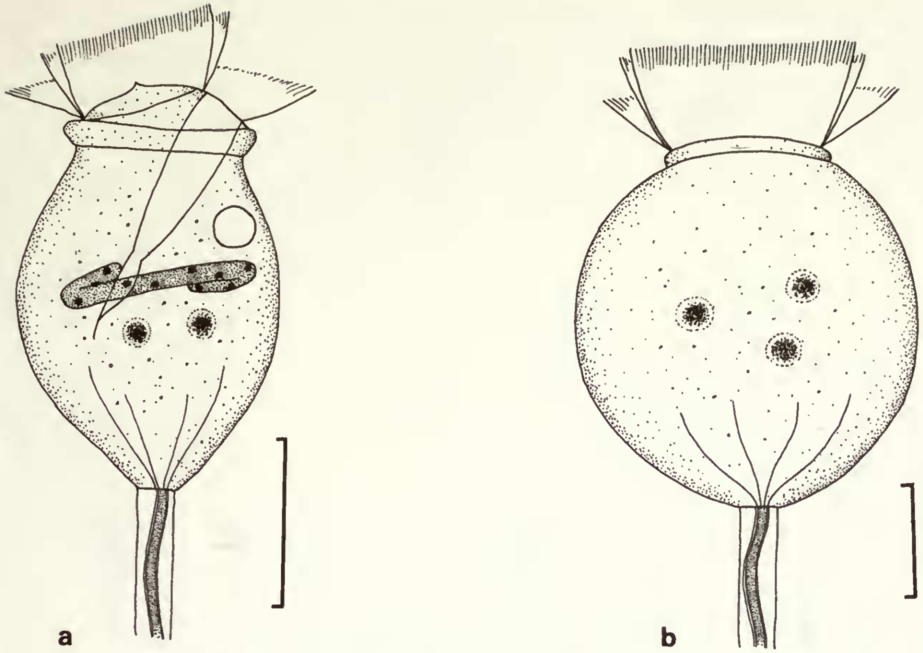

Fig. 18. (a) *V. globosa* (after Nenninger, 1948), bar = 25 µm; (b) *V. globularia* (after Kent, 1880–82), bar = 50 µm.

V. gracilis Dujardin, 1841

DIAGNOSIS (Figs 19a & b). Zooid 50–70 µm long × 25–35 µm wide, elongated trumpet-shaped and not constricted below peristomial lip which measures 35–40 µm across; disc convex and obliquely raised above peristome; infundibulum broad and reaches centre of zooid; C.V. situated just beneath peristome and empties into ventral wall of infundibulum; macronucleus J-shaped and situated longitudinally in body with upper arm lying across peristome; pellicle finely striated and with concave ribbing between striations; stalk up to 350 µm long and has a twisted sheath; thecoplasmic granules are present on spasmoneme; telotroch slender with prominent epistomial membrane.

HABITAT. Freshwater; recently redescribed by Foissner (1979).

V. granulata Kahl, 1933

DIAGNOSIS (Fig. 19c). Zooid 50–60 µm long × 30–35 µm wide, constricted below peristomial lip which measures 20 µm across; disc slightly convex; infundibulum short; C.V. situated in upper one-third of body; macronucleus long, C-shaped and lies longitudinally with respect to major axis of zooid; pellicle finely striated with irregular granules on surface; stalk up to 250 µm long.

HABITAT. Marine.

V. halophila Stiller, 1941

DIAGNOSIS (Fig. 20a). Zooid 40–50 µm long × 30–35 µm wide, inverted bell-shaped and constricted below wide peristomial lip which measures 38–40 µm across; two C.V.'s situated in peristomial region, both emptying into left hand wall of infundibulum; macronucleus long and slender and lies longitudinally with respect to major axis of zooid; pellicle distinctly striated and has convex ribbing between striations; stalk up to 250 µm long.

HABITAT. Freshwater, often attached to detritus where it may form large pseudocolonies.

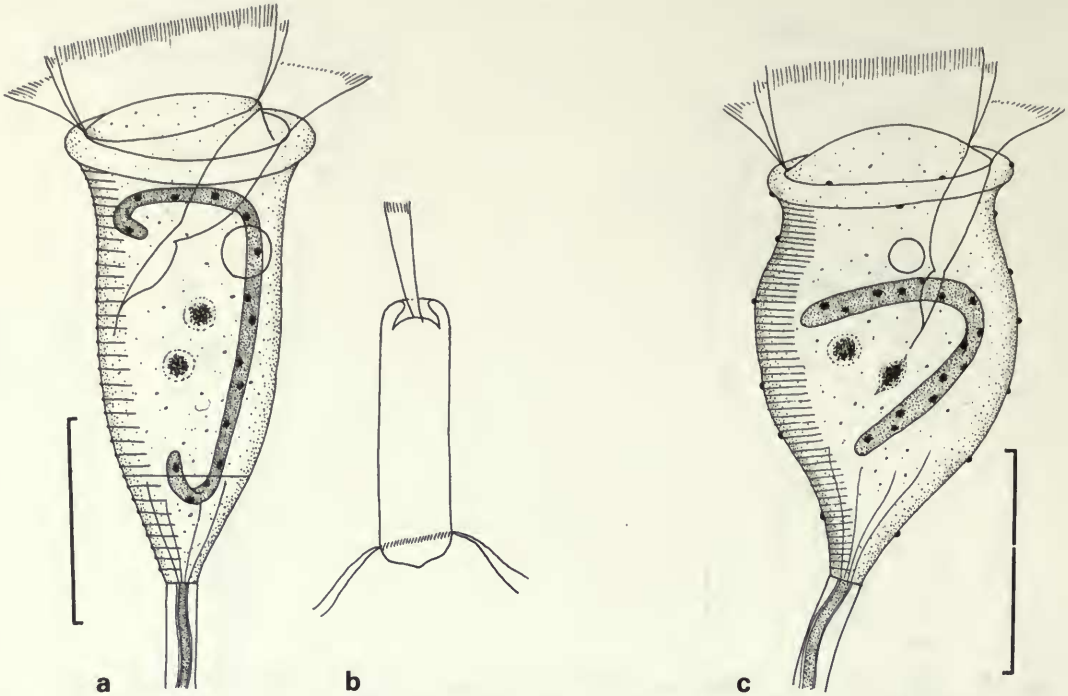

Fig. 19. (a) *V. gracilis* zooid; (b) telotroch (after Foissner, 1979), bar = 25 μm; (c) *V. granulata* (after Stiller, 1935), bar = 25 μm.

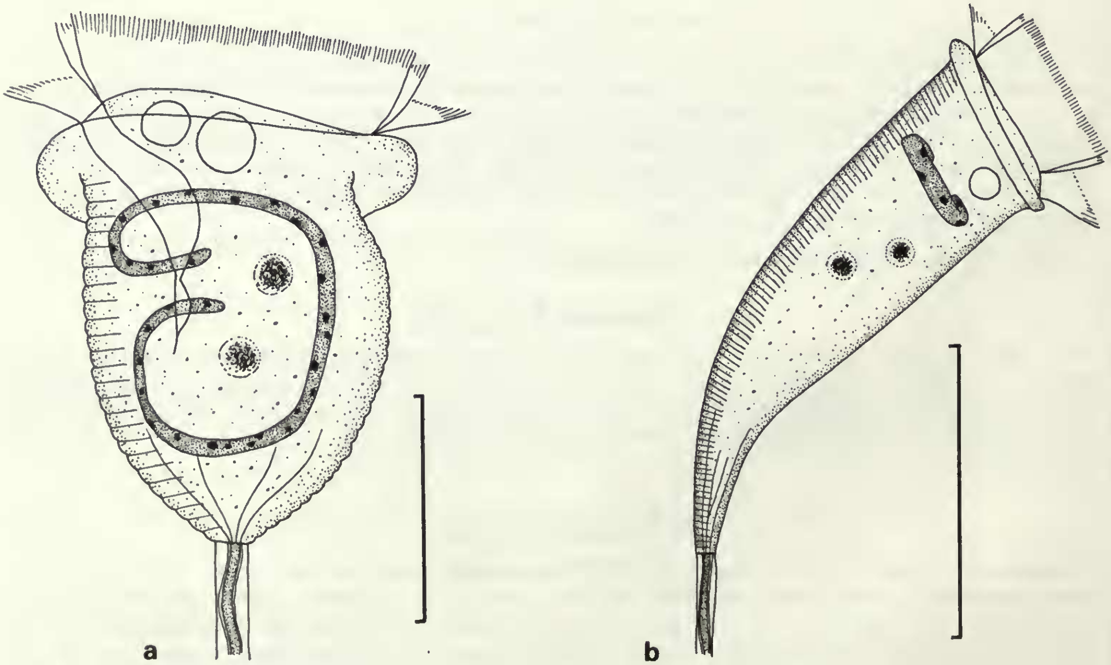

Fig. 20. (a) *V. halophila* (after Stiller, 1941), bar = 25 μm; (b) *V. hamata* (after Kahl, 1935), bar = 25 μm.

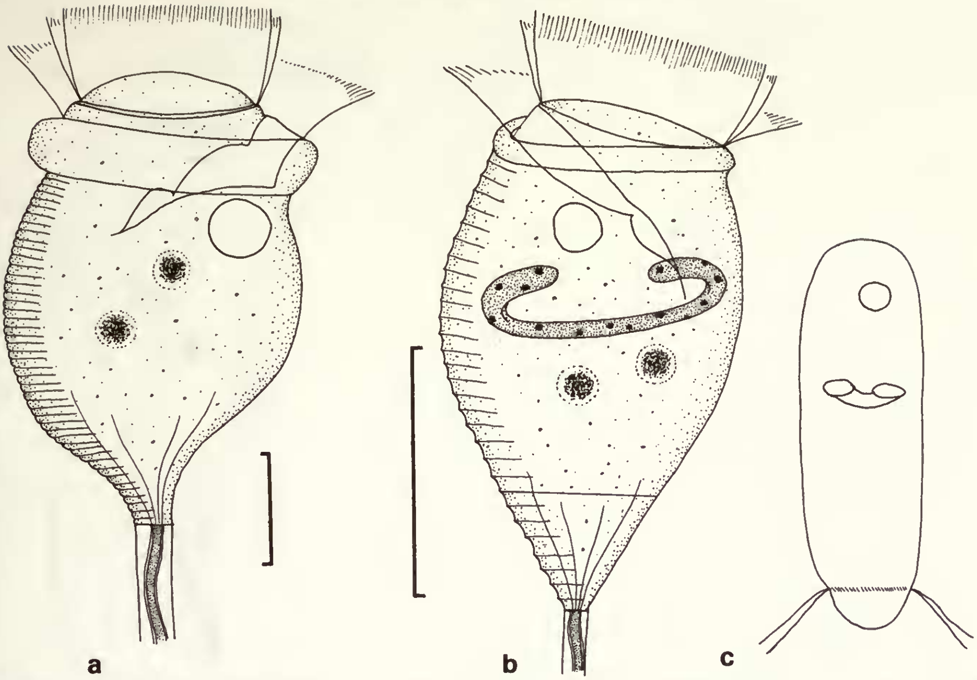

Fig. 21. (a) *V. incisa* (after Stiller, 1938), bar = 25 µm; (b) *V. infusionum* zooid; (c) telotroch (after Küsters, 1974), bar = 25 µm.

V. hamata Ehrenberg, 1831

V. delicatulata Biernacka, 1963

Diagnosis (Fig. 20b). Zooid 40 µm long × 15 µm wide, elongate and typically curved though not constricted below peristomial lip which measures 18 µm across; disc flat and obliquely elevated above peristome; C.V. situated just beneath peristome; macronucleus C-shaped and lies transversely across upper one-third of body; pellicle faintly striated.

Habitat. Marine or freshwater; solitary.

V. incisa Stiller, 1938

Diagnosis (Fig. 21a). Zooid 65–80 µm long × 50–55 µm wide and sharply constricted below peristomial lip which measures 50–60 µm across; disc prominently arched above peristome; infundibulum short and broad; C.V. situated just below peristome and empties into ventral wall of infundibulum via a short channel; macronucleus C-shaped and lies transversely across upper part of body; pellicle finely striated and has convex ribbing between the striations; stalk up to 150 µm long; thecoplasmic granules are present on spasmoneme.

Habitat. Freshwater, forming large pseudocolonies.

V. infusionum Dujardin, 1841

V. abbreviata (Keiser, 1921) Kahl, 1935
V. striata var. *octava* f. *utriculus* (Stokes 1885) Noland & Finley, 1931
V. utriculus (Stokes, 1885) Noland & Finley, 1931

Diagnosis (Figs 21b & c). Zooid 35–60 µm long × 18–30 µm wide, constricted beneath peristomial lip which measures 15–20 µm across; infundibulum short; C.V. situated just below peristome; macronucleus C-shaped and lies transversely across centre of body; pellicle distinctly striated and has concave ribbing.

Habitat. Freshwater or marine.

Remarks. Redescribed with biometric analysis by Foissner (1979).

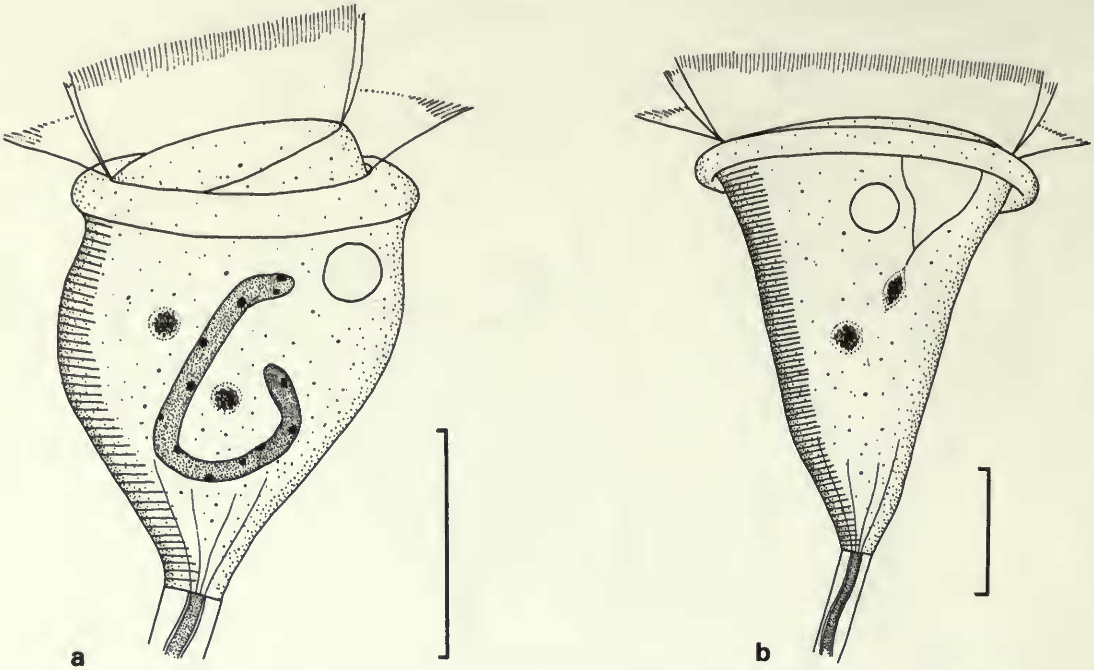

Fig. 22. (a) *V. jaerae* (after Precht, 1935), bar = 25 µm; (b) *V. kenti* (after Stiller, 1938), bar = 50 µm.

V. jaerae Precht, 1935

Diagnosis (Fig. 22a). Zooid 40–53 µm long × 30–40 µm wide, inverted bell-shaped and constricted below peristomial lip which measures 35–40 µm across; disc flat and obliquely elevated above peristome; C.V. situated in upper one-third of body; macronucleus long, irregularly shaped and twisted; pellicle distinctly striated; stalk up to 120 µm long.

Habitat. Marine, forming pseudocolonies attached to the crustacean *Jaera marina*.

V. kenti (Kent, 1881) Kahl, 1935

V. floridensis Stokes, 1886
V. spectrabilis Kent, 1881

Diagnosis (Fig. 22b). Zooid 170 µm long × 60 µm wide, elongated trumpet-shaped and not constricted below peristomial lip which measures 100–120 µm across; disc flat; infundibulum short; C.V. situated just beneath peristome; pellicle finely striated; stalk up to 500 µm long.

Habitat. Freshwater ponds, often forming large pseudocolonies.

V. latifunda Nenninger, 1948

Diagnosis (Fig. 23a). Zooid 60 µm long × 30 µm wide, barrel-shaped and constricted below thick peristomial lip which measures 30 µm across; disc flat and slightly elevated; infundibulum reaches $\frac{1}{4}$ body length; C.V. situated in upper one-third of zooid; macronucleus thick, C-shaped and lies transversely across centre of zooid; pellicle finely striated; stalk up to 420 µm long.

Habitat. Freshwater, originally found as an epibiont attached to the crustaceans *Lestes sponsa* and *L. virens*.

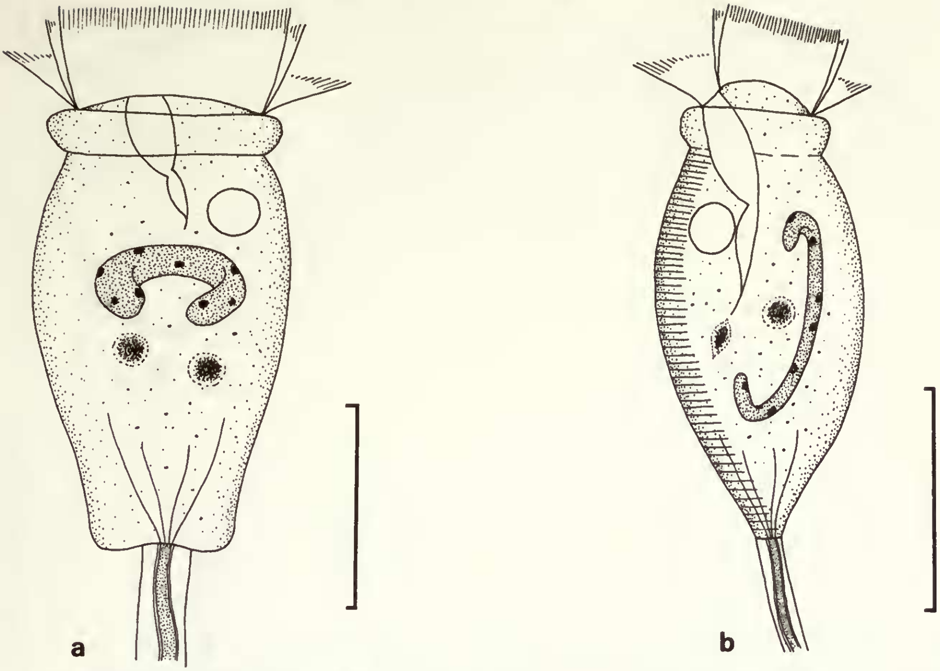

Fig. 23. (a) *V. latifunda* (after Nenninger, 1948), bar = 25 µm; (b) *V. lichenicola* (after Penard, 1922), bar = 25 µm.

V. lichenicola Greeff, 1888

V. inconstantans Green, 1974.

Diagnosis (Fig. 23b). Zooid 50–65 µm long × 25–30 µm wide, somewhat elongate and constricted beneath peristomial lip which measures 20 µm across; infundibulum reaches centre of body; C.V. situated in upper one-third of zooid, close to infundibulum; macronucleus irregular or C-shaped and usually lies longitudinally in lower ½ of body; pellicle finely striated; stalk up to 65 µm long.

Habitat. Freshwater, attached to lichen, mosses or sand particles and occasionally epibiotic attached to the crustacean *Macrothrix hirsuticornis*.

V. lima Kahl, 1933

Pseudovorticella lima (Kahl, 1933) Jankowski, 1976.

Diagnosis (Fig. 24a). Zooid 60–70 µm long × 30 µm wide, usually curved and constricted beneath well developed peristomial lip which measures 25 µm across; disc convex and slightly elevated above peristome; infundibulum short; C.V. lies in upper one-third of body close to ventral wall of infundibulum; macronucleus long, C-shaped and situated longitudinally with respect to major axis of body; pellicle distinctly striated with concave ribbing between the striations, and furnished with small refractile granules.

Habitat. Marine.

V. limnetis Stokes, 1885

Diagnosis (Fig. 24b). Zooid 50 µm long × 35 µm wide, inverted bell-shaped and constricted below peristomial lip which measures 35 µm across; disc convex and obliquely elevated above peristome; infundibulum broad and reaches one-third body length; C.V. lies beneath peristome and empties into ventral wall of infundibulum; macronucleus C-shaped and lies transversely across centre of body; pellicle distinctly striated with concave ribbing between striations; stalk sheath twisted.

Habitat. Freshwater.

Remarks. Redescribed with biometric analysis by Foissner (1979).

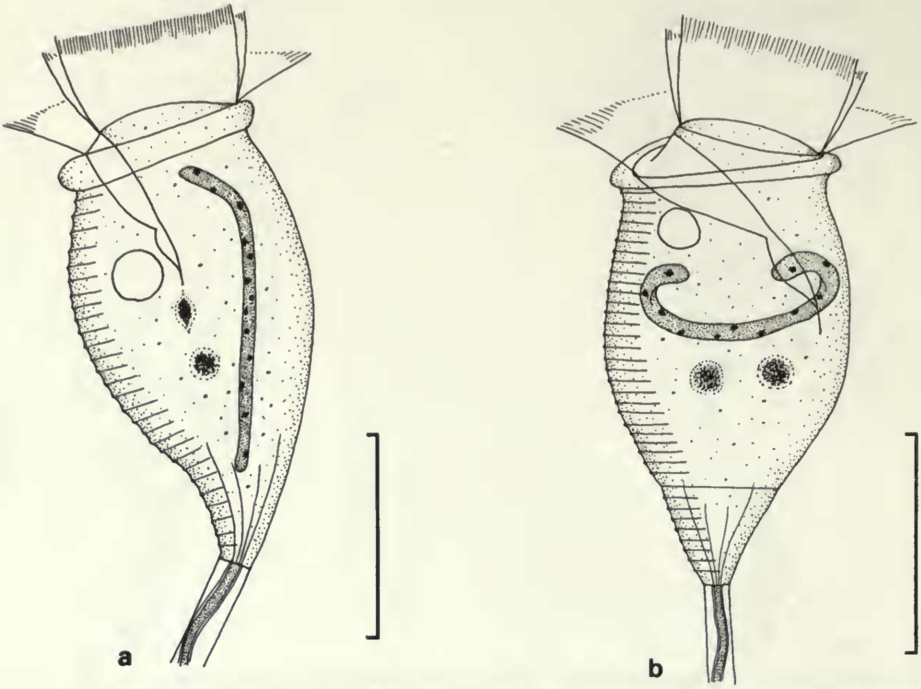

Fig. 24. (a) *V. lima* (after Kahl, 1935), bar = 25 μm; (b) *V. limnetis* (after Foissner, 1979), bar = 25 μm.

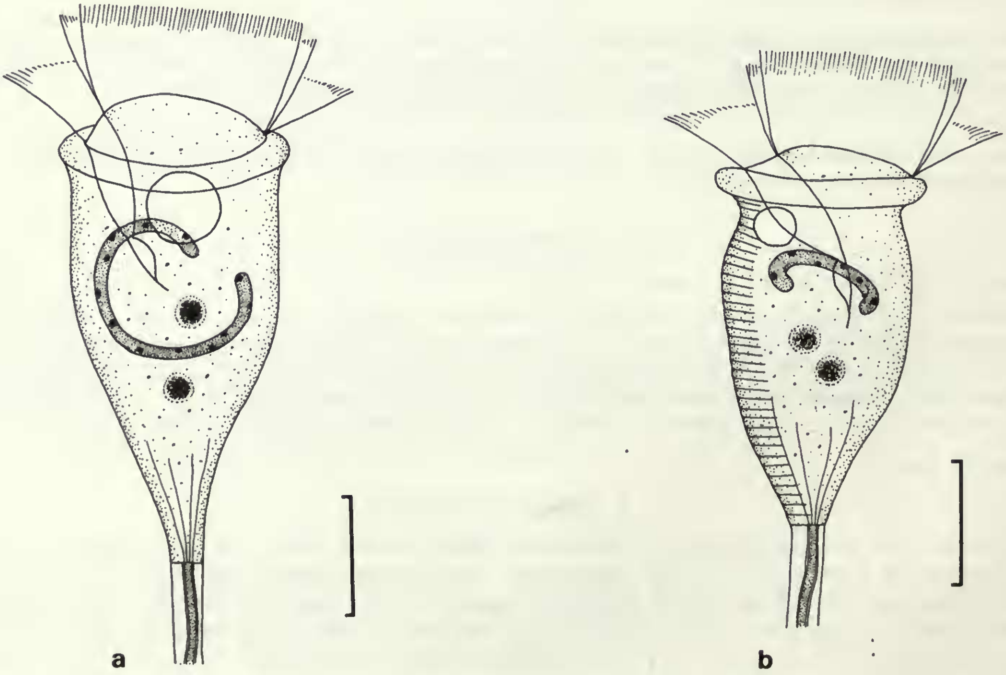

Fig. 25. (a) *V. longifilum* (after Stiller, 1971), bar = 25 μm; (b) *V. longiseta* (after Dietz, 1964), bar = 25 μm.

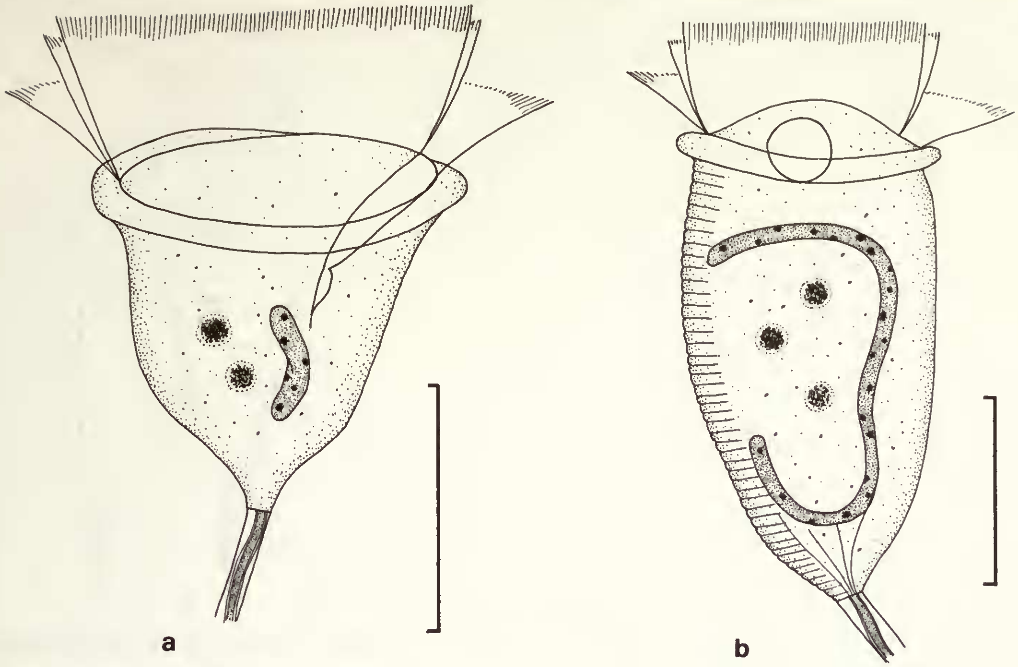

Fig. 26. (a) *V. longitricha* (after Gajewskaja, 1933), bar = 25 µm; (b) *V. lutea* (after Stiller, 1938), bar = 50 µm.

V. longifilum Kent, 1881

V. crassicaulis Nenninger, 1948
V. longifilum f. *epizooicum* Szczepanowski, 1978
V. macrocaulis (Stokes, 1885) Noland & Finley, 1931
V. simplex Nenninger, 1948

DIAGNOSIS (Fig. 25a). Zooid 80–90 µm long × 30–35 µm wide, inverted bell-shaped with constriction below peristomial lip which measures 45 µm across; disc prominently arched above peristome; infundibulum short; C.V. lies beneath peristomial lip; macronucleus C-shaped and situated longitudinally in upper two-thirds of body; pellicular striations not visible; stalk slender and up to 1000 µm long.

HABITAT. Freshwater, solitary; occasionally epibiotic.

V. longiseta Dietz, 1964

DIAGNOSIS (Fig. 25b). Zooid 82 µm long × 50 µm wide, elongate and constricted below peristomial lip which measures 65 µm across; disc flat and obliquely elevated; infundibulum broad and reaches one-third body length; C.V. lies beneath peristome and empties into infundibulum via short channel; macronucleus C-shaped and situated transversely across centre of zooid; pellicle finely striated with convex ribbing between striations.

HABITAT. Marine.

V. longitricha Gajewskaja, 1933

DIAGNOSIS (Fig. 26a). Zooid 30 µm long × 25 µm wide, inverted bell-shaped with no constriction below peristomial lip which measures 30–35 µm across; disc prominently arched above peristome; infundibulum reaches one-third body length; C.V. situated just below peristome and empties into infundibulum; macronucleus short, C-shaped and lies longitudinally in centre of zooid; pellicle finely striated; stalk up to 90 µm long.

HABITAT. Marine, originally found as an epibiont attached to gammarids.

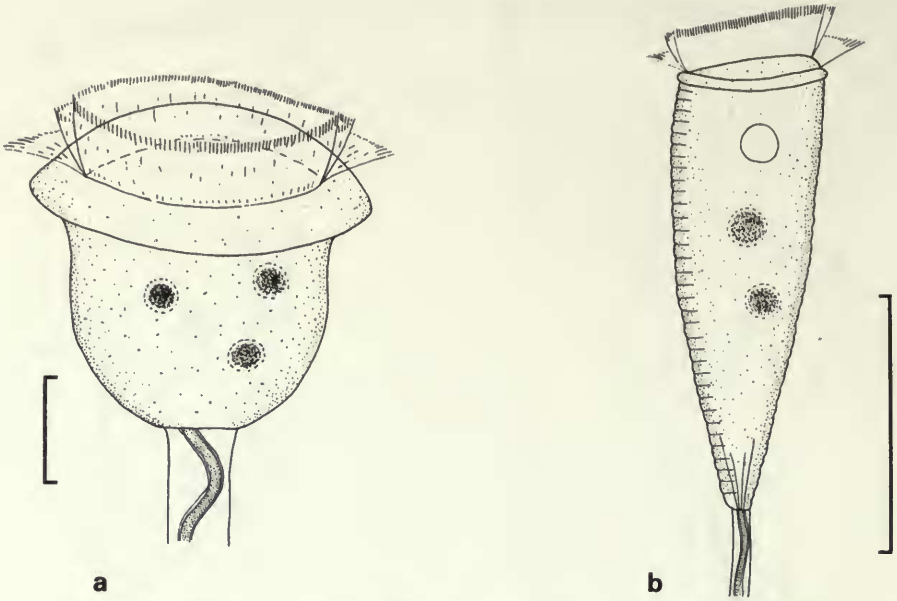

Fig. 27. (a) *V. lymnaearum* (after Viljoen & As, 1983), bar = 10 µm; (b) *V. macrophya* (after Stokes, 1885*b*), bar = 25 µm.

V. lutea Stiller, 1938

Diagnosis (Fig. 26b). Zooid 140 µm long × 75–80 µm wide and almost cylindrical in shape; peristomial lip 80–90 µm across; disc convex; infundibulum reaches one-third body length; C.V. situated just beneath peristome and empties into dorsal wall of infundibulum; macronucleus long, J-shaped and situated longitudinally with respect to major axis of body; pellicle distinctly striated and with convex ribbing between striations; stalk up to 700 µm long.

Habitat. Freshwater, originally found attached to the pond weed *Myriophylum*.

V. lymnaearum Viljoen & As, 1983

Diagnosis (Fig. 27a). Zooid 26–30 µm long (mean 28·3 µm) × 25–35 µm wide (mean 29·0 µm), inverted bell-shaped with a broad peristomial lip (45 µm in diameter); peristomial disc convex; macronucleus C-shaped and lies horizontally with respect to major body axis; pellicle striated.

Habitat. Freshwater, originally isolated from Westdene Dam, Johannesburg, South Africa attached to the shell of the mollusc, *Lymnaea natalensis*.

V. macrophya Stokes, 1885

Diagnosis (Fig. 27b). Zooid 38 µm long × 15–20 µm wide, elongate and almost cylindrical in shape; not constricted beneath peristomial lip which measures 15–20 µm across; disc flat and obliquely elevated; macronucleus short, C-shaped and lies in upper one-third of body; pellicle finely striated with convex ribbing between striations; stalk up to 60 µm long.

Habitat. Freshwater, originally isolated from pond water in North America; solitary.

V. macrostyla Schmarda, 1854

Diagnosis (Fig. 28a). Zooid 50 µm long × 30 µm wide, barrel-shape with a narrow peristomial lip which measures 20–25 µm in diameter; pellicle with up to 100 striations; stalk 750–1000 µm long.

Habitat. Freshwater.

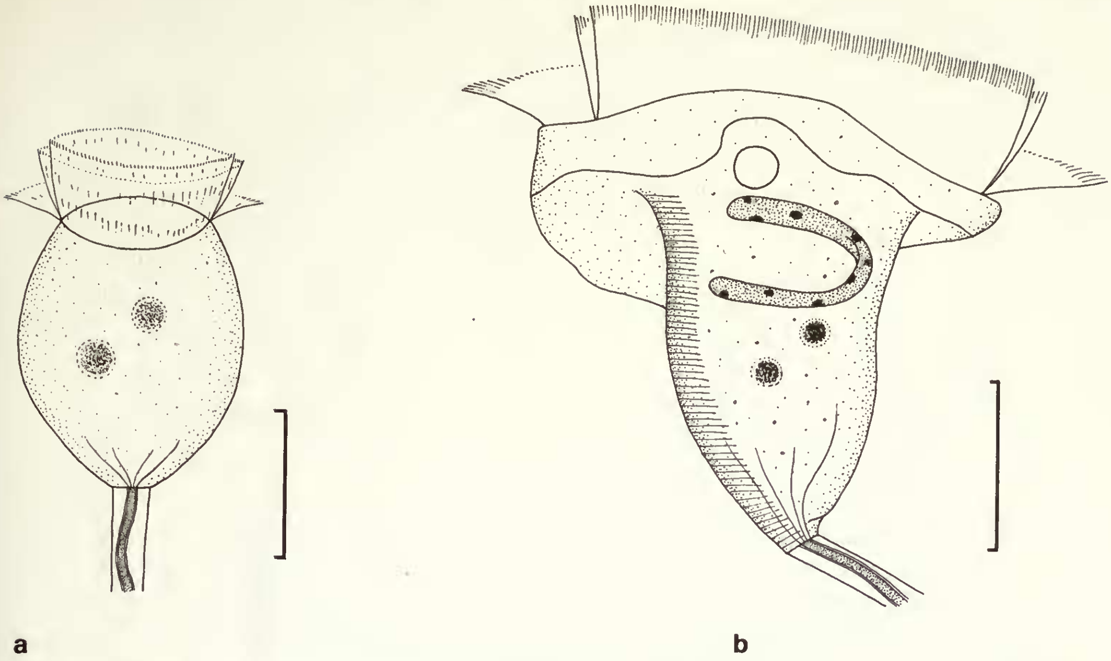

Fig. 28. (a) *V. macrostyla* (after Schmarda, 1854), bar = 25 µm; (b) *V. marginata* (after Stiller, 1931), bar = 25 µm.

V. marginata Stiller, 1931

V. marginata f. *poliensis* (Stiller) Szczepanowski, 1978
V. marginata f. *minor* (Stiller) Szczepanowski, 1978

Diagnosis (Fig. 28b). Zooid 70–90 µm long × 32–45 µm wide, elongate and slightly constricted below peristomial lip which is thin but very wide measuring 100–110 µm across; disc broad, flat and obliquely elevated above peristome; infundibulum short, broad and lies almost horizontally across peristomial region; C.V. empties into right hand wall of infundibulum; macronucleus long, C-shaped and situated transversely in upper $\frac{1}{2}$ of body; pellicle finely striated; stalk up to 270 µm long.

Habitat. Freshwater.

V. marina Greeff, 1870

V. minuta Precht, 1935

Diagnosis (Fig. 29a). Zooid 35–65 µm long × 40–50 µm wide, inverted bell-shaped and sharply constricted below peristomial lip which measures 40–50 µm across; disc flat and obliquely elevated above peristome; infundibulum short; C.V. large and situated just beneath peristome; macronucleus long, C-shaped and lies transversely across centre of zooid; pellicle distinctly striated; stalk up to 300 µm long.

Habitat. Marine; forms pseudocolonies.

Remarks. This species has been redescribed by Stiller (1935) and Küsters (1974).

V. mayeri Fauré-Fremiet, 1920

Pelagovorticella mayeri (Fauré-Fremiet, 1920) Jankowski, 1980.

Diagnosis (Fig. 30). Zooid 35 µm long × 30 µm wide, sharply curved and constricted beneath peristomial lip which measures 25 µm across; disc convex and elevated obliquely above peristome; infundibulum broad and reaches centre of zooid; macronucleus C-shaped and lies transversely across centre of zooid; pellicle

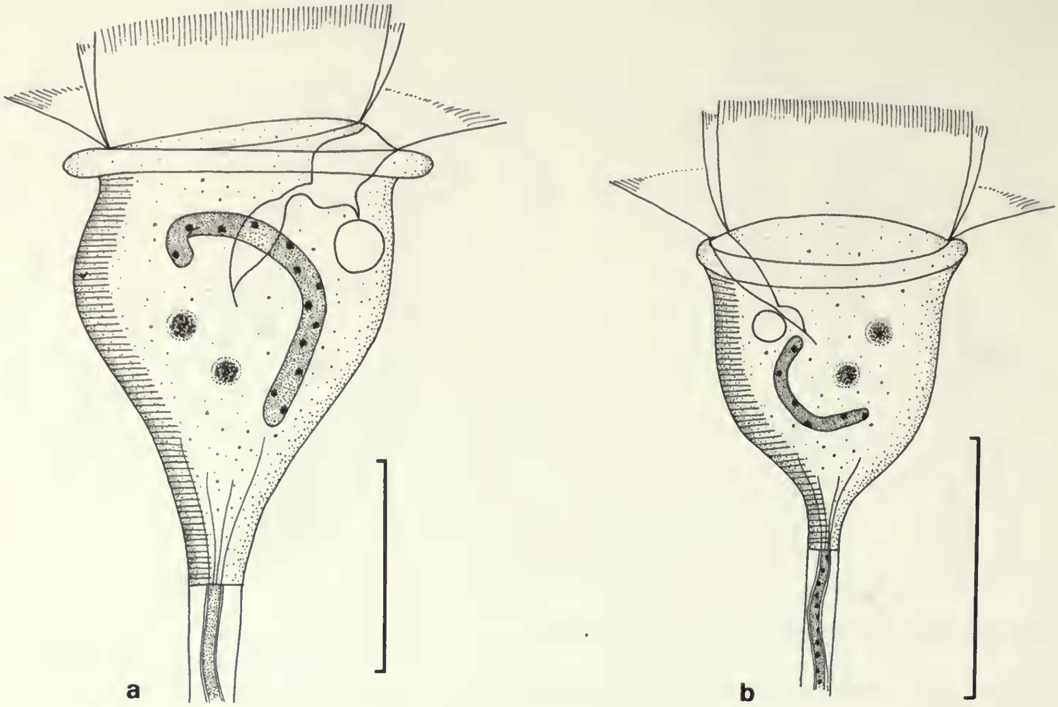

Fig. 29. (a) *V. marina* (after Küsters, 1974), bar = 25 µm; (b) *V. microscopica* (after Stiller, 1971), bar = 10 µm.

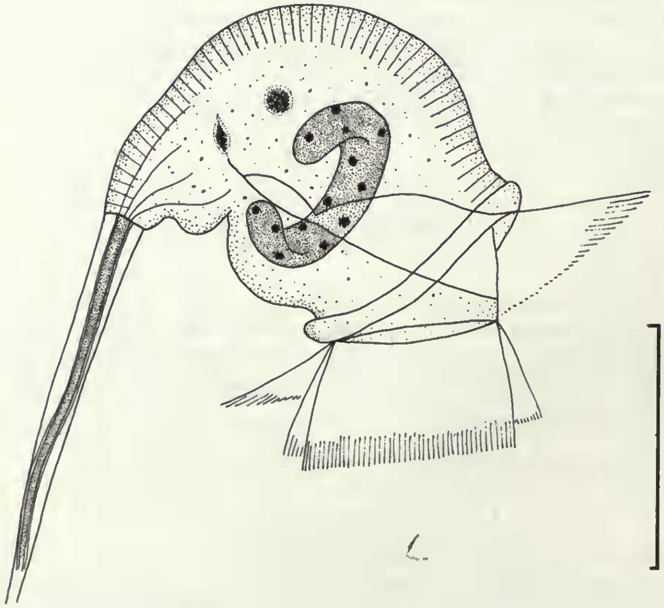

Fig. 30. *V. mayeri* (after Fauré-Fremiet, 1920), bar = 25 µm.

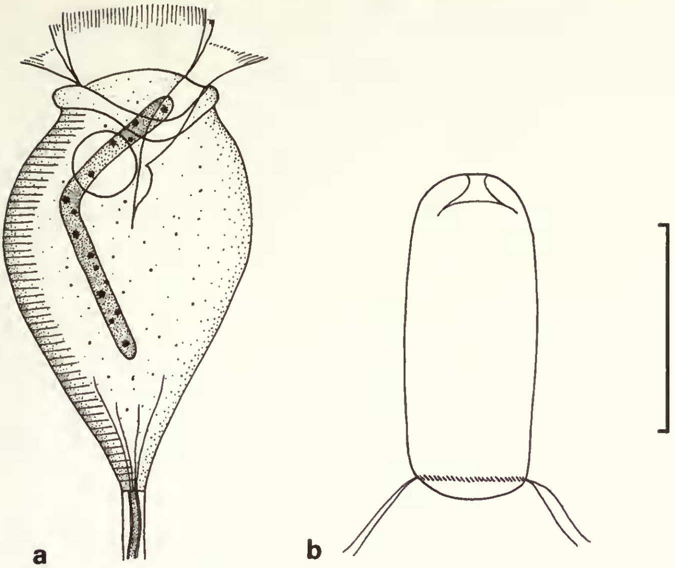

Fig. 31. (a) *V. microstoma* zooid; (b) telotroch (after Noland & Finley, 1931), bar = 25 µm.

distinctly striated; stalk up to 140 µm long and is never attached to a substratum but is used like a giant flagellum to aid swimming.

HABITAT. Marine or freshwater; pelagic.

V. microscopica Fromentel, 1874

DIAGNOSIS (Fig. 29b). Zooid 12 µm long × 8·0 µm wide, inverted bell-shaped but not constricted below peristomial lip which measures 10 µm across; pellicle striated; spasmoneme has red thecoplasmic granules.

HABITAT. Freshwater.

V. microstoma Ehrenberg, 1830

V. chydoricola Šramek-Hušek, 1946
V. constricta (Fromentel, 1874) Noland & Finley, 1931
V. cupifera (Kahl, 1935) Pratt & Rosen, 1983
V. cyclopicola Kahl, 1935
V. fluvialis (Fromentel, 1874) Noland & Finley, 1931
V. longimacronucleata Fukui & Morishita, 1961
V. magna Fukui & Morishita, 1961
V. mammillata (Fromentel, 1874) Noland & Finley, 1931
V. microstoma var. *defluviatilis* Nenninger, 1948
V. microstoma f. *turgescens* Stiller
V. partita Fukui & Morishita, 1961
V. pileolata Lepsi, 1948
V. submicrostoma Ghosh, 1922

DIAGNOSIS (Fig. 31). Zooid 35–96 µm long (mean 55 µm) × 22–50 µm wide (mean 35 µm), constricted beneath peristomial lip which measures 12–25 µm across (mean 23 µm); disc convex; infundibulum reaches one-third body length; C.V. empties into ventral wall of infundibulum; macronucleus long, C-shaped and lies longitudinally with respect to major axis of body; pellicle distinctly striated; stalk up to 380 µm long (mean 90 µm) × 1·5–4·0 µm wide (mean 3·0 µm).

HABITAT. Freshwater, especially stagnant waters, activated sludge and areas of high organic content; occasionally epibiotic.

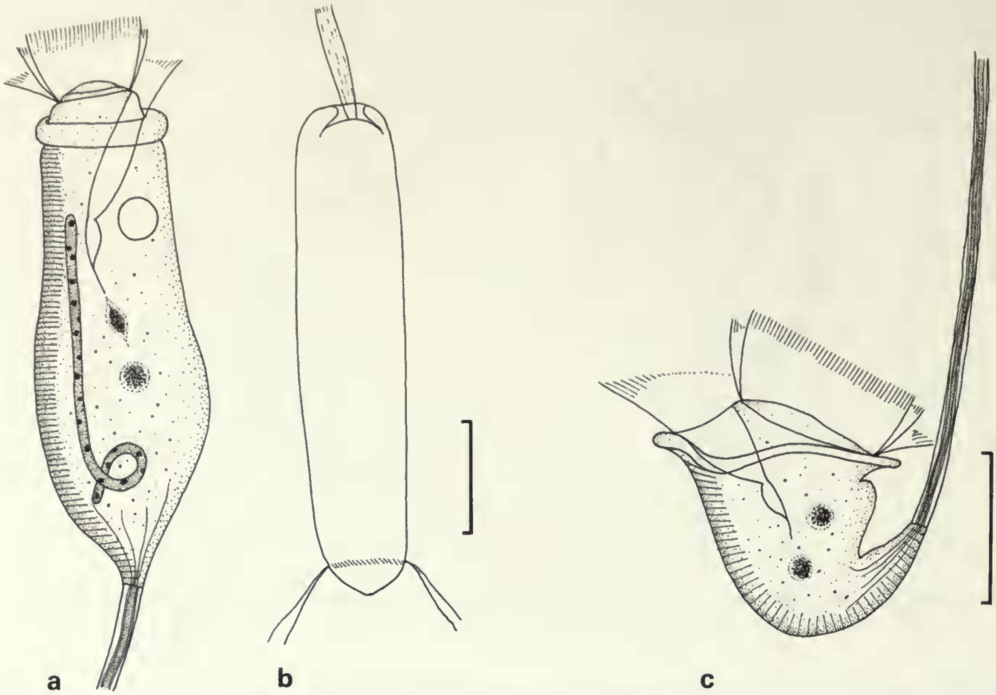

Fig. 32. (a) *V. muralis* zooid; (b) telotroch (after Penard, 1922), bar = 25 µm; (c) *V. natans* (after Fauré-Fremiet, 1924), bar = 50 µm.

V. muralis Penard, 1922

Diagnosis (Figs 32a & b). Zooid 90–125 µm long × 35–45 µm wide, elongate but with distinct bulge in distal part of body and constricted below peristomial lip which measures 25 µm across; disc narrow and prominently arched above peristome; infundibulum reaches one-third body length; C.V. lies just beneath peristome and close to infundibulum; macronucleus long, straight with ends folded back, and situated longitudinally with respect to major axis of body; pellicle finely striated; stalk slender and up to 100 µm long.

Habitat. Freshwater and *Sphagnum* bogs.

V. natans Fauré-Fremiet, 1924

Diagnosis (Fig. 32c). Zooid 100 µm long × 50 µm wide, inverted bell-shape though curved and slightly constricted below peristomial lip which measures 75 µm across; disc convex and prominently arched above peristome; pellicle distinctly striated; stalk up to 700 µm long and never attached to a substratum; animal swims by means of oral ciliature with stalk held projecting forwards.

Habitat. Freshwater, pelagic.

V. nutans Müller, 1773

V. gemella (Fromentel, 1874) Noland & Finley, 1931
V. procumbens (Fromentel, 1874) Noland & Finley, 1931

Diagnosis (Fig. 33a). Zooid 60–80 µm long × 25–30 µm wide, elongate and held in characteristic nodding position on stalk; body constricted below peristomial lip which measures 30 µm across; disc prominently arched above peristome; C.V. situated in upper one-third of body; macronucleus long, thin and lies longitudinally with respect to major axis of body; pellicular striations not visible; stalk up to 320 µm long.

Habitat. Freshwater or marine.

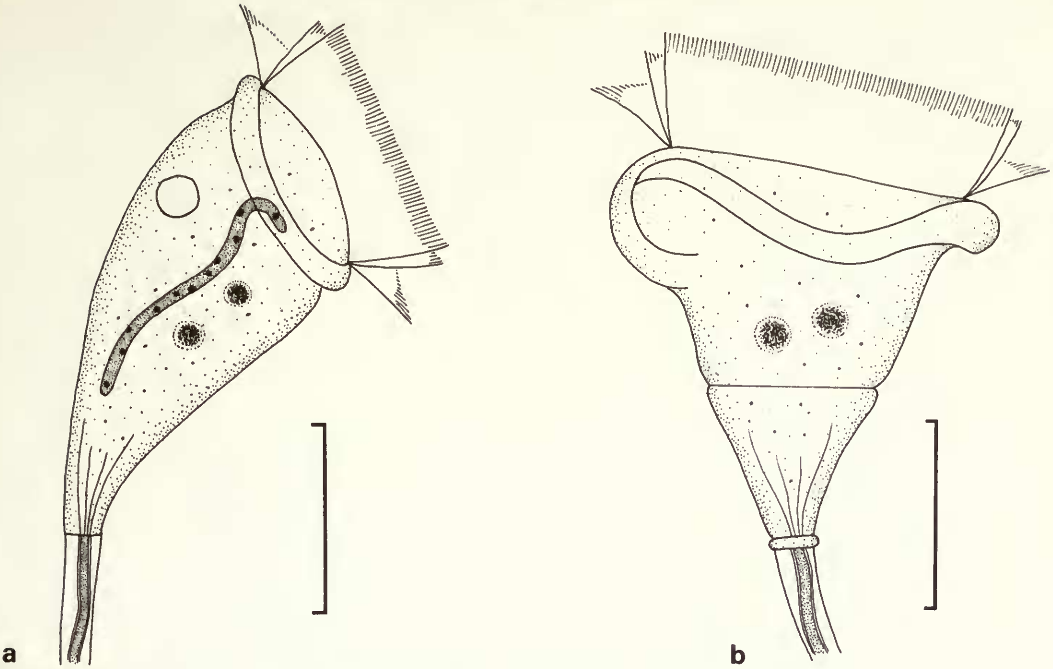

Fig. 33. (a) *V. natans* (after Curds, 1969), bar = 25 µm; (b) *V. obconica* (after Dons, 1915), bar = 25 µm.

V. obconica (Dons, 1915) Kahl, 1935

V. conica Dons, 1915

Diagnosis (Fig. 33b). Zooid 55 µm long × 45 µm wide, inverted bell-shaped but not constricted below peristomial lip which measures 55 µm across; pellicle has distinct ridge in region of telotroch band; stalk up to 90 µm long.

Habitat. Marine.

V. operculariformis Foissner, 1979

Diagnosis (Fig. 34a). Zooid 45–55 µm long × 30–50 µm wide, constricted below peristomial lip which measures 15 µm across; disc convex; infundibulum short; C.V. situated in upper one-third of body and empties into ventral wall of infundibulum; macronucleus C-shaped, curved in ring-like manner and lies transversely across the centre of the zooid; pellicle distinctly striated with concave ribbing between the striations; stalk up to 250 µm long.

Habitat. Freshwater, originally isolated from rainwater pools.

V. ovum Dons, 1918

V. incerta Nenninger, 1948.

Diagnosis (Fig. 34b). Zooid 90 µm long × 50–55 µm wide, somewhat rotund and constricted beneath peristomial lip which measures 35 µm in diameter; disc slightly convex; c.v. lies in upper $\frac{1}{2}$ of body; pellicular striations not visible; stalk up to 7·0 µm wide × 90 µm long (see remarks).

Habitat. Marine or freshwater, occasionally epibiotic.

Remarks. The original description was made from a partially contracted specimen.

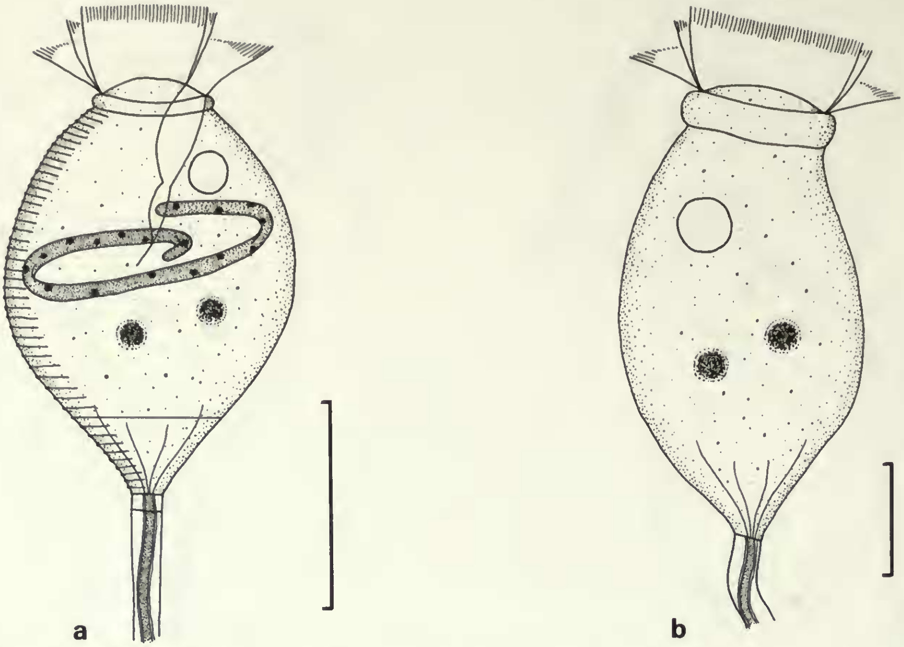

Fig. 34. (a) *V. opculariformis* (after Foissner, 1979), bar = 25 µm; (b) *V. ovum* (after Dons, 1918), bar = 25 µm.

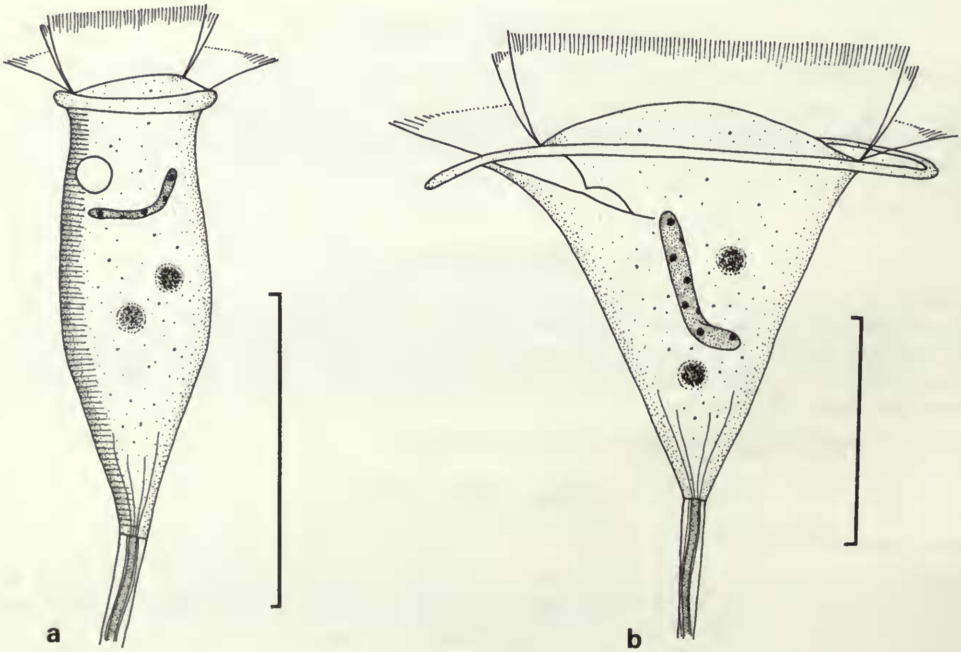

Fig. 35. (a) *V. parasita* (after Stokes, 1887*b*), bar = 25 µm; (b) *V. patellina* (after Kent, 1880–82), bar = 25 µm.

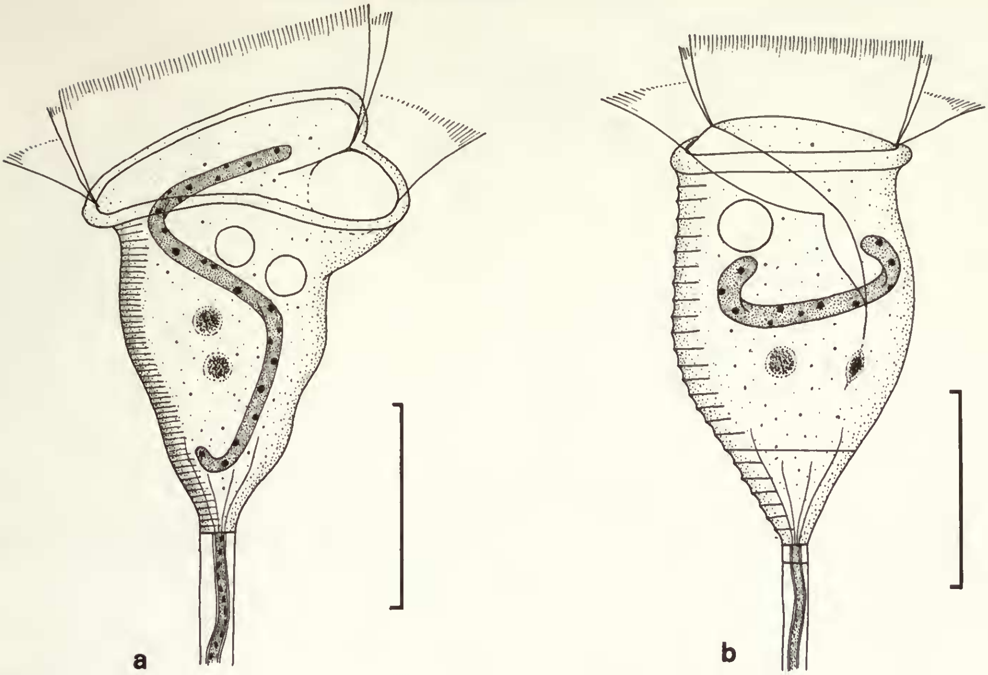

Fig. 36. (a) *V. picta* (after Noland & Finley, 1931), bar = 25 µm; (b) *V. platysoma* (after Foissner, 1979), bar = 10 µm.

V. parasita Stokes, 1887

V. ephemerae Kahl, 1935

DIAGNOSIS (Fig. 35a). Zooid 40 µm long × 10 µm wide, elongate and constricted beneath peristomial lip which measures 15 µm in diameter; disc flat and obliquely elevated above peristome; c.v. situated in upper one-third of body; macronucleus C-shape and lies transversely across upper one-third of body; pellicle finely striated; stalk up to 150 µm long.

HABITAT. Freshwater, occasionally epibiotic.

V. patellina Müller, 1776

V. fornicata (Dons, 1915) Noland & Finley, 1931

DIAGNOSIS (Fig. 35b). Zooid 90 µm long × 60 µm wide, conical in shape with no constriction below the wide peristomial lip which measures 90 µm across; disc convex; infundibulum short; macronucleus short, C-shaped and situated longitudinally in centre of zooid; pellicular striations not visible; stalk up to 360 µm long.

HABITAT. Marine; forms pseudocolonies.

V. picta Ehrenberg, 1831

V. appunctata (Fromentel, 1874) Noland & Finley, 1931
V. picta var. *major* Nenninger, 1948
V. plicata (Fromentel, 1874) Noland & Finley, 1931

DIAGNOSIS (Fig. 36a). Zooid 41–63 µm long (mean 58 µm) × 20–37 µm wide (mean 32 µm), inverted bell-shaped and slightly constricted beneath peristomial lip which measures 35–50 µm across (mean 45 µm); disc convex; two C.V.'s situated in upper one-third of body; macronucleus long, J-shaped and situated longitudinally in zooid with upper arm lying horizontally across the peristome; pellicle finely striated; stalk

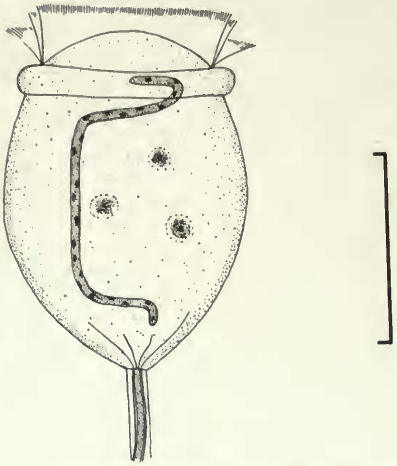

Fig. 37. *V. poznaniensis* (after Piesik, 1976), bar = 50 µm.

4·0–7·0 µm wide (mean 5·9 µm) and up to 550 µm long (mean 340 µm); spasmoneme has row of highly refractile thecoplasmic granules which may be either red or green.

Habitat. Freshwater; forms pseudocolonies.

V. platysoma Stokes, 1887

Diagnosis (Fig. 36b). Zooid 25 µm long × 15 µm wide, inverted bell-shaped and slightly constricted below peristomial lip which measures 18 µm across; disc flat and obliquely elevated; infundibulum broad and reaches centre of zooid; C.V. situated in upper one-third of body and empties into ventral wall of infundibulum; macronucleus C-shaped and lies transversely across centre of zooid; pellicle distinctly striated and with concave ribbing between striations.

Habitat. Freshwater; occasionally epibiotic.

Remarks. Redescribed by Foissner (1979) with biometric analysis.

V. poznaniensis Piesik, 1976

Diagnosis (Fig. 37). Zooid inverted bell-shaped, 68–85 µm long × 62–68 µm wide; constricted beneath peristomial lip the diameter of which is about equal to the maximum body width; disc convex; one c.v.; macronucleus J-shaped and typically very thin; pellicular striations not visible; stalk 7 µm wide.

Habitat. Freshwater, attached to crayfish and *Cyclops* sp.

V. pulchella Sommer, 1951

Diagnosis (Fig. 38a). Zooid 46 µm long × 30 µm wide, somewhat rotund and constricted beneath peristomial lip which measures 20 µm across; disc narrow and prominently arched above peristome; infundibulum reaches $\frac{3}{4}$ body length; C.V. centrally located and empties into infundibulum; macronucleus short, C-shaped and lies transversely across centre of zooid; pellicle distinctly striated and has convex ribbing between the striations.

Habitat. Freshwater, originally found as an epibiont attached to the crustacean, *Cyclops* sp.

V. pulchra Kahl, 1933

Diagnosis (Fig. 38b). Zooid 40–50 µm long × 20 µm wide, inverted bell-shaped and strongly constricted below peristomial lip which measures 25 µm across and is furnished with a row of short, pointed projections; disc flat and obliquely elevated above peristome; cilia long and prominent; infundibulum short; C.V. centrally located; macronucleus long, C-shaped and lies longitudinally with respect to major axis of body; pellicle distinctly striated.

Habitat. Marine.

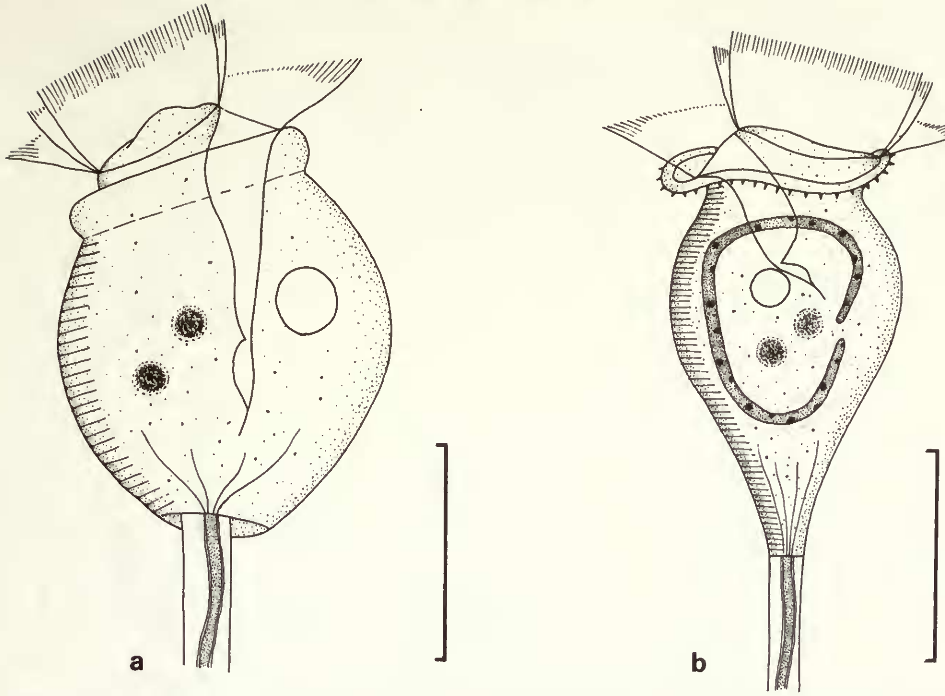

Fig. 38. (a) *V. pulchella* (after Sommer, 1951), bar = 25 µm; (b) *V. pulchra* (after Kahl, 1935), bar = 25 µm.

V. pyriforme Stiller, 1939

V. intermissa Nenninger, 1948

Diagnosis (Fig. 39a). Zooid 45–70 µm long × 30–40 µm wide, inverted bell-shaped with slight constriction beneath peristomial lip which measures 35 µm across; disc flat and slightly elevated; infundibulum broad and reaches centre of zooid; C.V. situated in upper one-third of body; macronucleus C-shaped and lies transversely across centre of zooid; pellicular striations not visible; stalk up to 400 µm long.

Habitat. Freshwater or marine.

V. quadrangularis Kent, 1881

V. sinuata (Zacharias, 1903) Noland & Finley, 1931
V. zealandica (Kirk, 1887) Noland & Finley, 1931

Diagnosis (Fig. 35b). Zooid 200 µm long × 60 µm wide, elongate and with a characteristic constriction in the central region; the body is also constricted beneath the peristomial lip which measures 65 µm across; disc flat and obliquely elevated; C.V. situated beneath peristome; pellicle finely striated; stalk slender and up to 300 µm long.

Habitat. Freshwater ponds, often forming large pseudocolonies.

V. rhabdophora Stokes, 1885

Diagnosis (Fig. 40a). Zooid 80 µm long × 30 µm wide, asymmetrical with one side almost straight while the other has a prominent bulge; disc flat; macronucleus long, J-shaped and situated longitudinally in body with upper arm lying horizontally across peristome; pellicle finely striated and has a mucilagenous covering which contains numerous rod-shape bacteria; stalk up to 160 µm long.

Habitat. Freshwater.

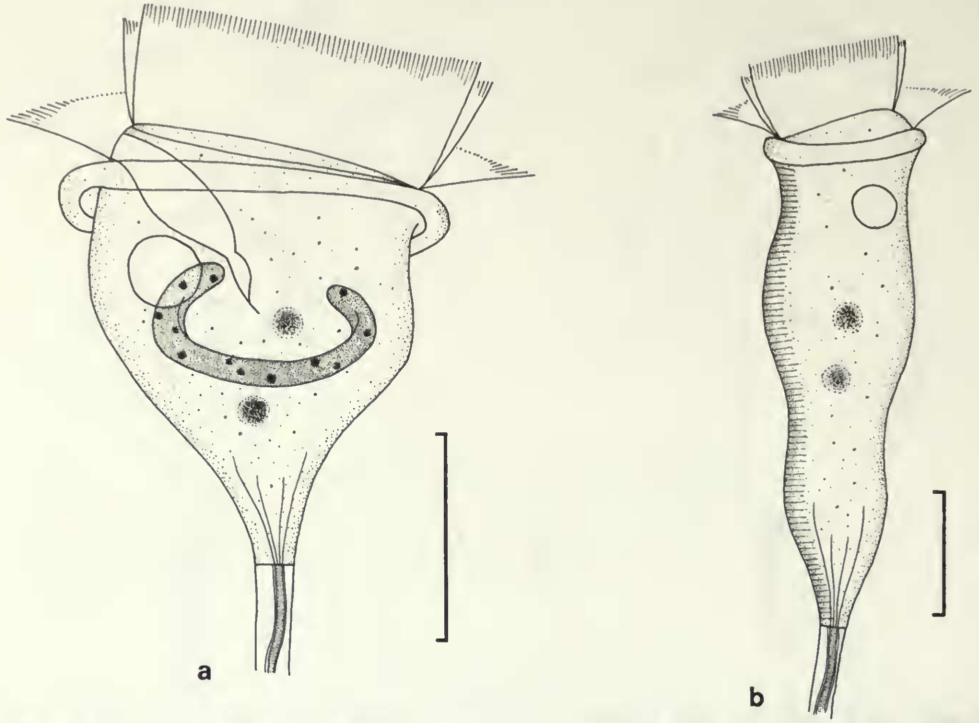

Fig. 39. (a) *V. pyriforme* (after Stiller, 1935), bar = 25 µm; (b) *V. quadrangularis* (after Kent, 1880–82), bar = 50 µm.

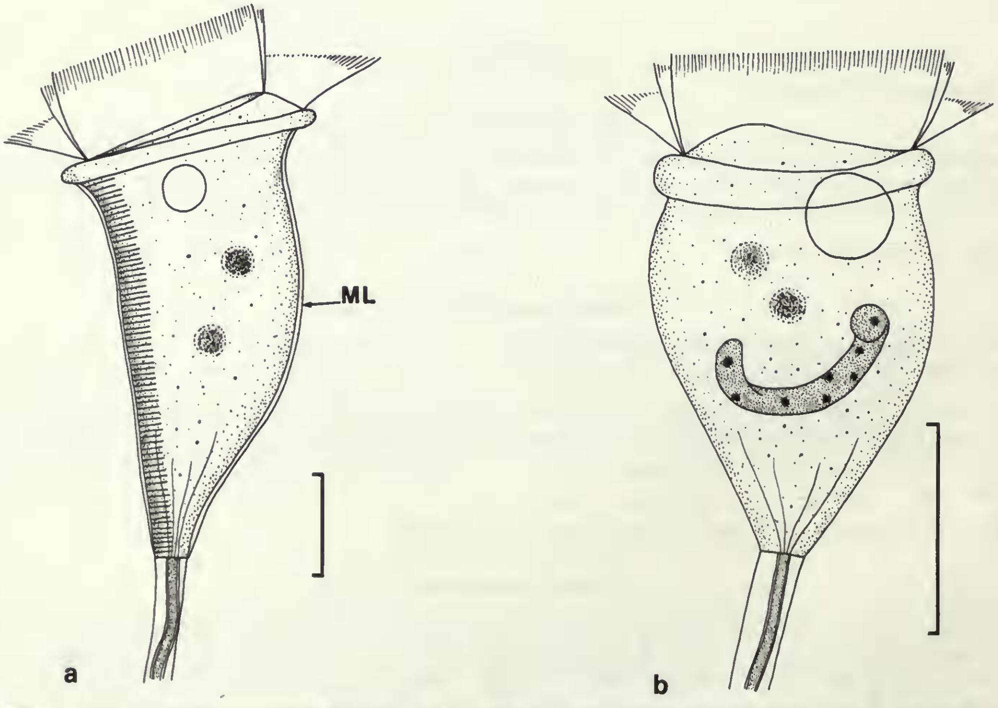

Fig. 40. (a) *V. rhabdophora* (after Stokes, 1885*c*), bar = 25 µm, ML = mucus layer; (b) *V. rotunda* (after Nenninger, 1948), bar = 25 µm.

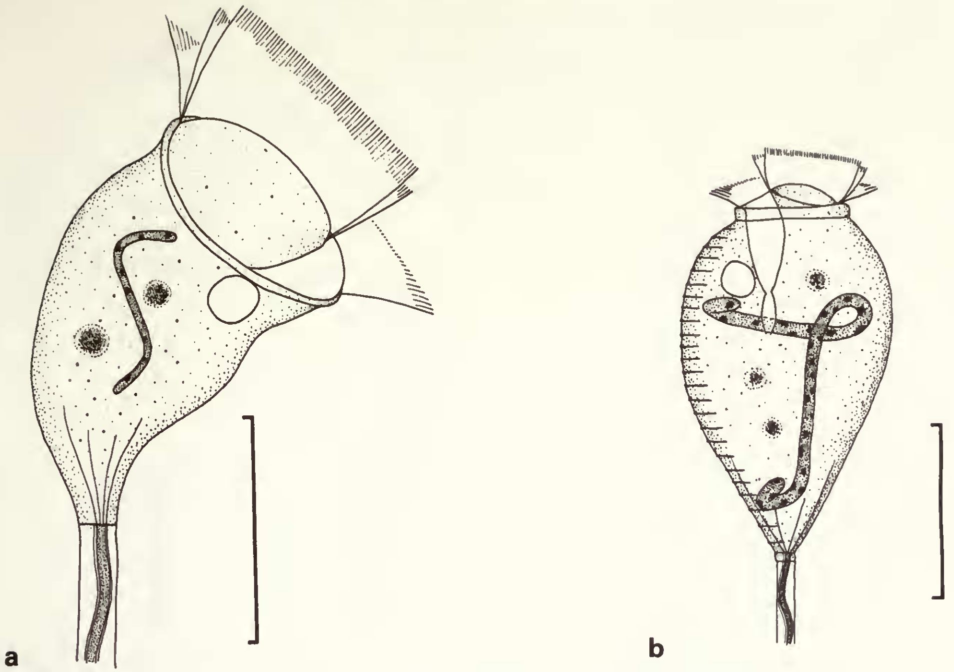

Fig. 41. (a) *V. rubristigma* (after Kellicott, 1888), bar = 25 µm; (b) *V. sepulcreti* (after Foissner & Schiffmann, 1975), bar = 50µm.

V. rotunda Nenninger, 1948

V. octava var. *asellicola* Stiller, 1953

Diagnosis (Fig. 40b). Zooid 49 µm long × 30 µm wide, inverted bell-shaped with slight constriction below peristomial lip which measures 30 µm across; disc convex; C.V. situated in upper one-third of body; macronucleus C-shaped and lies transversely across centre of zooid; pellicular striations not observed.

Habitat. Freshwater, originally found as an epibiont attached to the crustacean *Lestes* sp.

V. rubristigma Kellicott, 1888

Diagnosis (Fig. 41a). Zooid 35 µm long × 20 µm wide, curved and slightly constricted beneath peristomial lip which measures 25 µm across; disc flat and obliquely elevated; C.V. situated just below peristome; macronucleus S-shaped and lies longitudinally in centre of body; pellicular striations not visible; stalk up to 300 µm long; spasmoneme has several rows of red thecoplasmic granules.

Habitat. Freshwater, solitary.

V. sepulcreti Foissner & Schiffmann, 1975

Diagnosis (Fig. 41b). Zooid 45–55 µm long × 25–30 µm wide; disc convex; peristomial lip collar-like and measures 15 µm in diameter; one c.v. situated in upper one-third of zooid close to infundibulum; macronucleus J-shaped; pellicle has a total of 38–43 (mean 40) striations with concave ribbing between striations; stalk up to 500 µm long.

Habitat. Freshwater.

V. striata Dujardin, 1841

V. aquae-dulcis (Stokes, 1887) Noland & Finley, 1931
V. conochili (Stokes, 1889) Noland & Finley, 1931

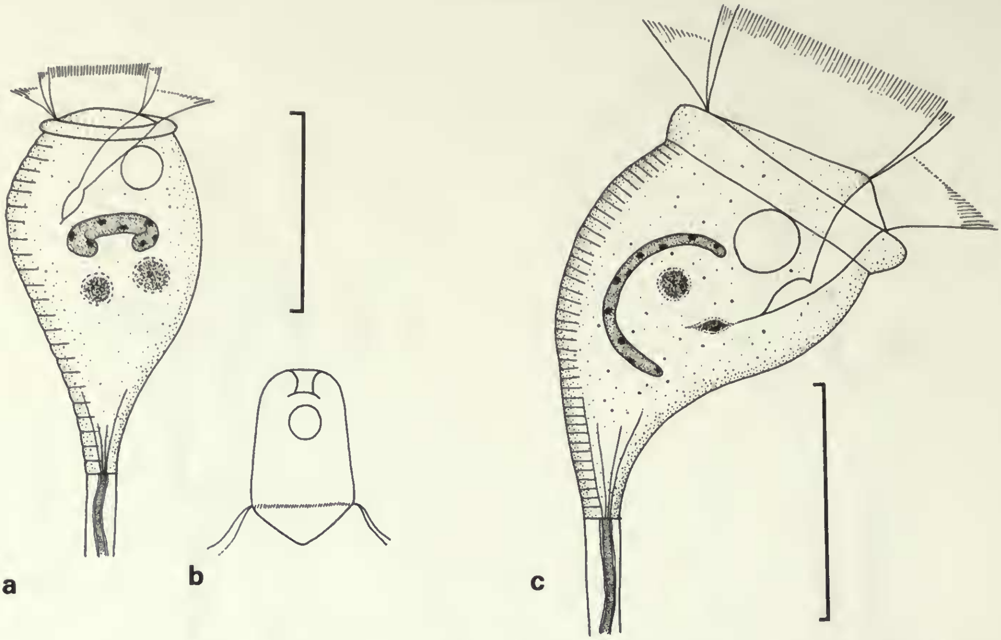

Fig. 42. (a) *V. striata* zooid; (b) telotroch (after Noland & Finley, 1931), bar = 25 µm; (c) *V. subprocumbens* (after Ghosh, 1922), bar = 25 µm.

V. latestriata Sommer, 1951
V. lemnae (Stokes, 1886) Noland & Finley, 1931
V. minima Stiller, 1939
V. oceanica (Zacharias, 1906) Noland & Finley, 1931
V. octava (Stokes, 1885) Noland & Finley, 1931
V. pulsilla (Stokes, 1887) Noland & Finley, 1931
V. pyrum (Mereschkowsky, 1879) Noland & Finley, 1931
V. pyum collaris Wang Jiaji, 1974
V. rhabdostyloides (Kellicott, 1885) Noland & Finley, 1931
V. striata var. *octava* Noland & Finley, 1931
V. striatula (Dons, 1915) Noland & Finley, 1931
V. suboctava Sommer, 1951

Diagnosis (Figs 42a & b). Zooid 20–50 µm long (mean 35 µm) × 15–32 µm wide (mean 19 µm); constricted beneath peristomial lip which measures 13–26 µm across (mean 18 µm); disc convex; C.V. situated just below peristome; macronucleus C-shaped and lies transversely across centre of body; pellicle distinctly striated and with convex ribbing between striations; stalk 1·6–4·0 µm wide (mean 3·0 µm) and up to 300 µm long (mean 100 µm).

Habitat. Freshwater or marine; solitary; occasionally epibiotic.

V. subprocumbens Ghosh, 1922

V. nana Kahl, 1933
V. solitaria Stiller, 1935

Diagnosis (Fig. 42c). Zooid 30–50 µm long × 20–30 µm wide, asymmetric and curved; slightly constricted below peristomial lip which measures 20–30 µm across; disc flat and obliquely elevated; infundibulum short; C.V. situated in upper one-third of body; macronucleus C-shaped and situated longitudinally with respect to major axis of body; pellicle distinctly striated; stalk up to 150 µm long.

Habitat. Freshwater or marine; solitary; occasionally epibiotic attached to *Lemna trisulca*.

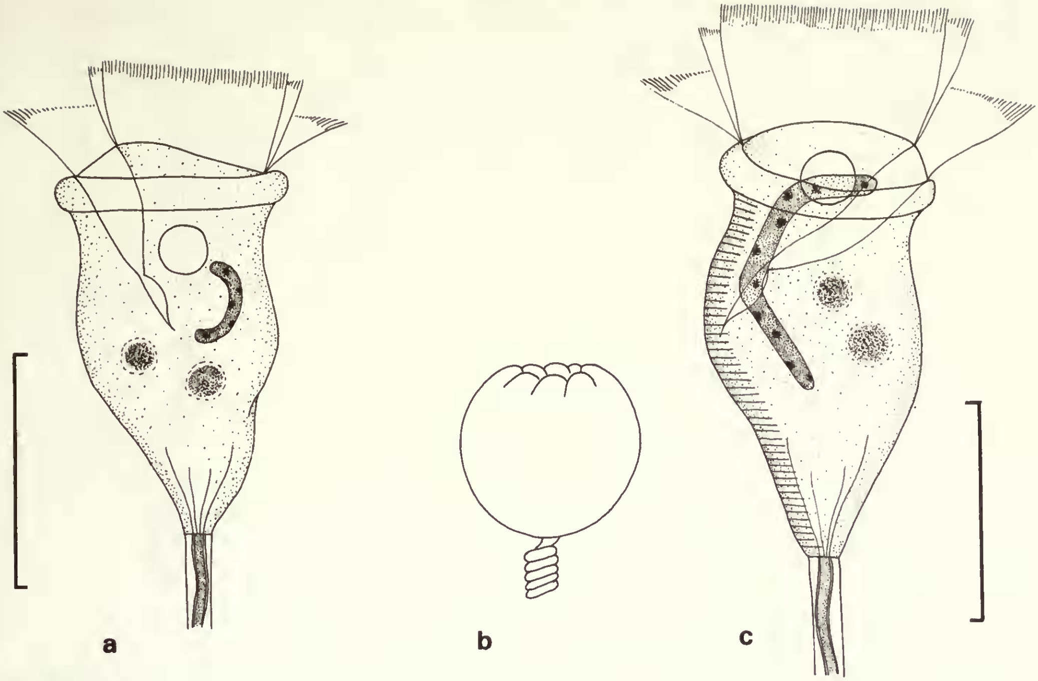

Fig. 43. (a) *V. subsinuata* (after Ghosh, 1922), bar = 25 µm; (b) *V. szczepanowskii*, contracted; (c) *V. szczepanowskii* (after Szczepanowski, 1978), bar = 25 µm.

V. subsinuata Ghosh, 1922

V. longipharyngae Szczepanowski, 1978

Diagnosis (Fig. 43a). Zooid 40–50 µm long × 35–40 µm wide, inverted bell-shaped and may or may not be constricted below peristomial lip which measures 40–45 µm across; infundibulum broad and short; C.V. situated in upper one-third of body; macronucleus short, curved and lies longitudinally in upper $\frac{1}{2}$ of zooid; stalk up to 30 µm long.

Habitat. Freshwater ponds.

V. szczepanowskii (Szczepanowski, 1978) nom. nov.

V. plicata Szczepanowski, 1978

Diagnosis (Fig. 43b). Zooid 43 µm long × 25 µm wide, elongate and constricted beneath peristomial lip which measures 25–30 µm across; disc prominently arched above peristome; macronucleus C-shaped and lies longitudinally in upper $\frac{1}{2}$ of body; pellicle distinctly striated and has convex ribbing.

Habitat. Freshwater, originally found as an epibiont attached to the crustacean *Asellus* sp.

V. telescopica Kent, 1861

V. telescopica var. *marina* Gourret & Roeser, 1886
V. telescopiformis (Gourret & Roeser, 1886) Kahl, 1935

Diagnosis (Fig. 44a & b). Zooid 50 µm long × 15 µm wide, elongate and slightly constricted beneath well developed peristomial lip which measures 15–20 µm across; infundibulum short; C.V. situated in upper one-third of body; macronucleus C-shaped and lies longitudinally in centre of zooid; pellicular striations not visible but there are two characteristic transverse ridges on the pellicle and below each of these, the body becomes abruptly narrower; during contraction, these portions of the zooid overlap; stalk slender and up to 50 µm long.

Habitat. Freshwater or marine; solitary.

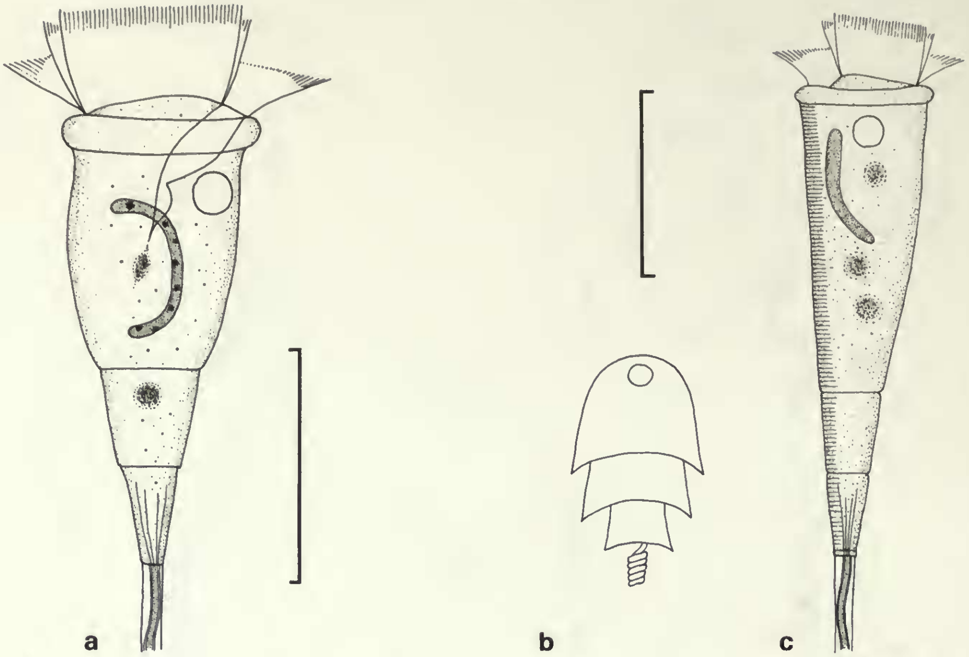

Fig. 44. (a) *V. telescopica* (after Kent, 1880–82), bar = 25 µm; (b) *V. telescopica*, contracted (after Kahl, 1935); (c) *V. telescopoides* (after Šramek-Hušek, 1948), bar = 25 µm.

V. telescopoides (Kahl, 1935) Šramek-Hušek, 1948

V. telescopica Kahl, 1935

DIAGNOSIS (Fig. 44b). Zooid elongate 55–70 µm long × 17–25 µm wide; peristomial lip narrow, 15–20 µm in diameter; disc flat or slightly convex; c.v. situated just beneath peristome; macronucleus short, C-shaped and situated in upper one-third of zooid; pellicle striated; two transverse pellicular ridges are present on lower $\frac{1}{4}$ of zooid and upon contraction the area of the zooid above each overlaps that below.

HABITAT. Freshwater.

REMARKS. *V. telescopoides* is the name given by Šramek-Hušek (1948*b*) to the animal which Khal (1935) isolated in Hamburg and tentatively identified as '*V. telescopia?*'. Šramek-Hušek (1948*b*) redescribed this species from specimens collected from Czechoslovakian rivers.

V. turgicula Wang Jiaji, 1977

DIAGNOSIS (Fig. 45a). Zooid 60–70 µm long × 52–64 µm wide, the middle portion being distinctly swollen; disc dome-shaped and prominently elevated above peristomial lip which measures 32–42 µm in diameter; one c.v. situated just beneath the peristome close to the infundibulum; macronucleus C-shaped and lies transversely across centre of zooid; pellicle faintly striated; stalk 180–315 µm long.

HABITAT. Freshwater, originally found attached to aquatic mosses.

V. venusta Nenninger, 1948

V. rotunda var. *asellicola* Stiller, 1953

DIAGNOSIS (Fig. 45b & c). Zooid 36 µm long × 25–30 µm wide, inverted bell-shaped but not constricted beneath peristomial lip which measures 30 µm in diameter; disc convex; c.v. lies in upper one-third of body in the niche formed by the C-shaped macronucleus; pellicle distinctly striated and has convex ribbing between striations; stalk up to 250 µm long; upon contraction the peristomial lip is drawn up in the shape of a narrow cylinder (Fig. 45c).

HABITAT. Freshwater, originally isolated as an epibiont on the crustacean *Asellus* sp.

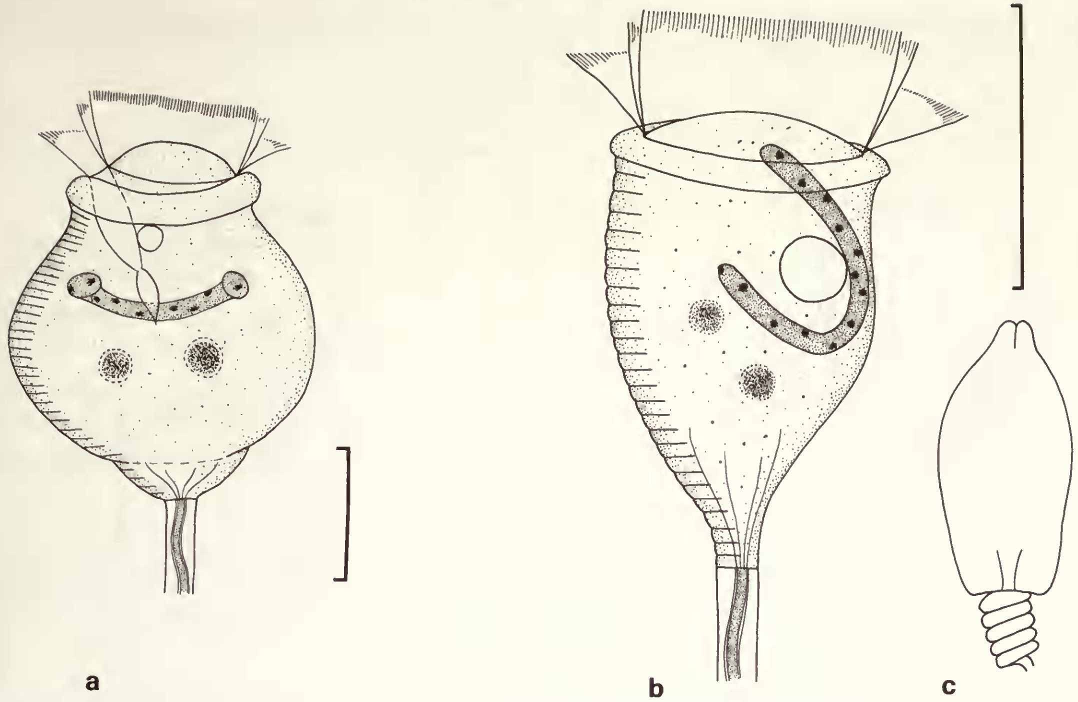

Fig. 45. (a) *V. turgicula* (after Wang Jiaji, 1977), bar = 25 µm; (b) *V. venusta* relaxed zooid; (c) contracted zooid (after Nenninger, 1948), bar = 25 µm.

V. vernalis Stokes, 1887

Diagnosis (Fig. 46a). Zooid 50 µm long × 30 µm wide, elongated trumpet-shaped with no constriction beneath well developed peristomial lip which measures 35 µm across; disc prominently arched above peristome; two C.V.'s situated in upper one-third of zooid; macronucleus long, C-shaped and lies longitudinally with respect to major axis of body; pellicular striations only visible in lower one-third of zooid; pellicle covered with irregularly arranged tubercles and granules; stalk up to 350 µm long.

Habitat. Freshwater ponds.

V. verrucosa Dons (1915), 1918

V. singularis Kahl, 1933

Diagnosis (Fig. 46b). Zooid 60 µm long × 55 µm wide, conical in shape and with no constriction beneath peristomial lip which measures 60 µm across; C.V. situated in upper one-third of body; macronucleus J-shaped with proximal region lying horizontally across peristome; pellicle is furnished with numerous randomly arranged tubercles of various sizes; pellicular striations not visible; stalk 8·0 µm wide and up to 40 µm long.

Habitat. Marine.

V. vestita Stokes, 1883

Pseudovorticella vestita (Stokes, 1883) Jankowski, 1976
V. chlamydophora Penard, 1922

Diagnosis (Fig. 47a). Zooid 50–75 µm long × 40–50 µm wide, inverted bell-shaped and not constricted beneath peristomial lip which measures 55 µm across; disc flat and slightly elevated above peristome; infundibulum reaches two-thirds body length; C.V. situated in upper one-third of zooid; macronucleus

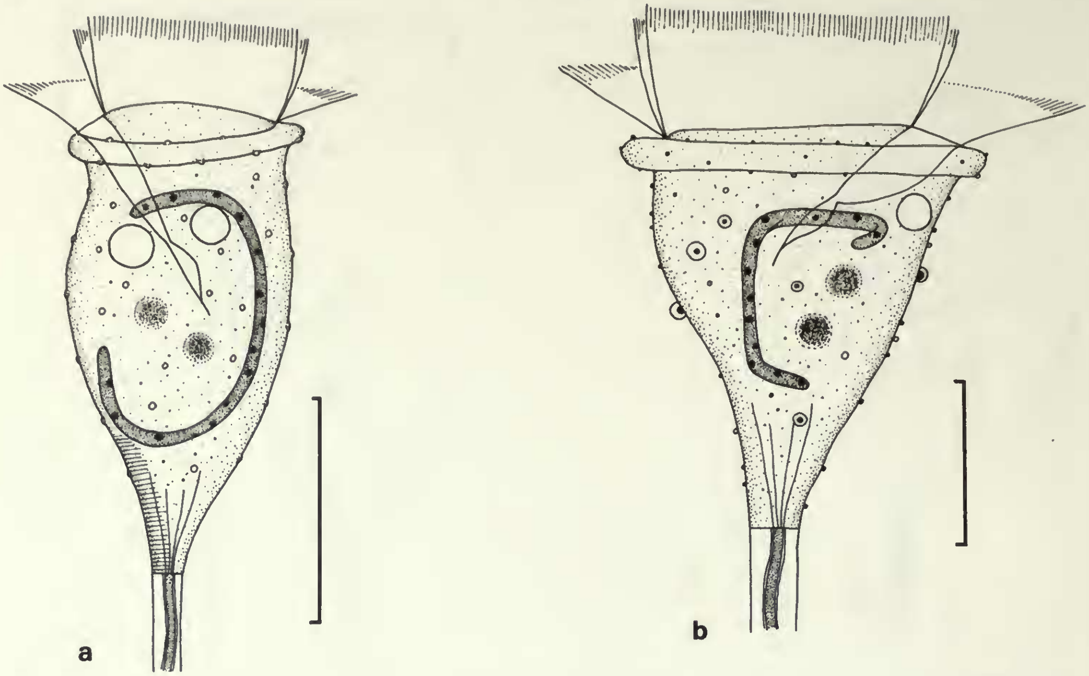

Fig. 46. (a) *V. vernalis* (after Stokes, 1887*b*), bar = 25 µm; (b) *V. verrucosa* (after Küsters, 1974), bar = 25 µm.

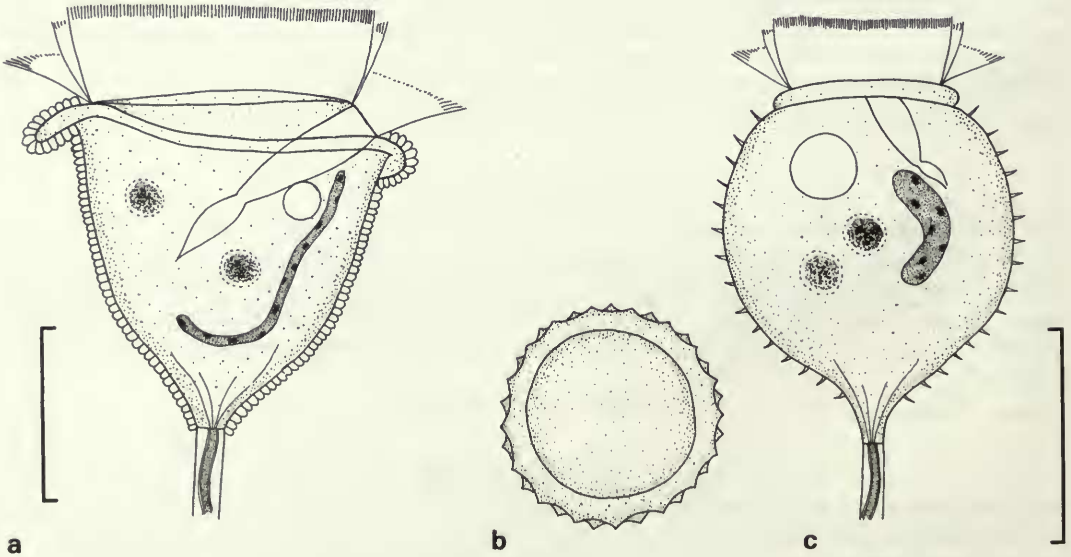

Fig. 47. (a) *V. vestita* (after Stokes, 1883), bar = 25 µm; (b) *V. voeltzkowi* cyst; (c) zooid (after King, 1931), bar = 25 µm.

lies longitudinally with respect to major axis of body; pellicle finely striated; entire zooid covered by transparent, membranous investment which is divided into compartments; stalk up to 400 µm long.

HABITAT. Freshwater, often forming large pseudocolonies.

REMARKS. According to Noland & Finley (1931) *V. vestita* has two C.V.'s but in his original description, Stokes (1883) indicated that only one C.V. is present.

V. voeltzkowi Sondheim, 1929

Pseudovorticella voeltzkowi (Sondheim, 1929) Jankowski, 1976
V. echina King, 1933

DIAGNOSIS (Fig. 47b). Zooid 30–40 µm long × 30–40 µm wide, somewhat rotund, but slightly elongated distally and constricted below peristomial lip which measures 15–20 µm across; disc flat; infundibulum short and broad; C.V. situated in upper one-third of body; macronucleus short, thick, C-shaped and lies longitudinally in centre of zooid; pellicle covered in short, pointed projections, 3·0–4·0 µm long; pellicular striations not visible; stalk up to 140 µm long.

HABITAT. Freshwater.

Addendum

Four new species of *Vorticella* were described by Banina (1983) from activated sludge at the Experimental Aeration Station, Petrodvorets, Old Peterhof, USSR. These are:

V. aerotenci Banina, 1983

DIAGNOSIS Zooid 90–140 µm long × 32–60 µm wide, elongate with upper part cylindrical and lower part rounded; not constricted beneath peristomial lip, the diameter of which is greater than the maximum body width; disc convex; single large c.v. situated in upper one-third of zooid; macronucleus C-shaped and lies longitudinally with respect to major body axis; cytoplasm granular; pellicle finely striated; stalk thick and up to 140 µm long.

V. geispicae Banina, 1983

DIAGNOSIS Zooid 68–122 µm long × 24–48 µm wide, upper part cylindrical and lower part cone-shaped; not constricted beneath peristomial lip, the diameter of which is slightly greater than the maximum body width; two c.v.'s situated in upper part of body; macronucleus slender and elongate with the upper end curved across the peristome and the lower end extending longitudinally down the body; pellicle finely striated; bundles of fibrils conspicuous in lower part of zooid radiating from scopula; stalk somewhat shorter than body length.

V. peterhoffi Banina, 1983

DIAGNOSIS Zooid 62–80 µm long × 35–46 µm wide, inverted bell-shaped and held at an angle on stalk; constricted beneath peristomial lip, the diameter of which is less than the maximum body width; disc slightly convex; infundibulum lies horizontally across upper part of zooid; single c.v. situated just below peristome; macronucleus thick, irregular or dumb-bell shaped and lies either obliquely or longitudinally with respect to major body axis; pellicular striations not observed; stalk length greater than zooid length.

V. hyalina Banina, 1983

DIAGNOSIS Zooid 96–100 µm long × 48–54 µm wide, inverted bell-shaped and constricted beneath peristomial lip, the diameter of which is equal to the maximum body width; disc flat; single c.v. situated in upper one-third of zooid; macronucleus slender and J-shaped; cytoplasm clear and transparent; pellicular striations not observed; stalk slender and several times longer than its body.

Reference

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Acknowledgements

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Appendix 1

Index of extant species; annotated list of nominal species.

The following list is composed of those species which were not rejected by Noland & Finley (1931) together with the 113 species and varieties described since. *Haplocaulis* Precht, 1935 and *Pseudovorticella* Foissner & Schiffmann, 1974, two genera which closely resemble *Vorticella*, have been erected since Noland & Finley's review and many species previously belonging to *Vorticella* have been transferred to these two. Instances of synonymy, homonymy and the rejection of taxa due to a lack of sufficient information are also indicated.

V. abbreviata (Keiser, 1921) Kahl, 1935 was regarded as a distinct species by both Kahl (1935), and Foissner & Schiffmann (1974), but is considered here to be a variant of *V. infusionum*.

V. aequilata Kahl 1935 (p. 11).

V. alba Fromentel, 1874 was erroneously moved to the genus *Haplocaulis* by Stiller (1971). It appears to be a valid species of *Vorticella* (p. 11).

V. aldabrandina Kaas, 1921 was so poorly figured and described that it cannot be recognised as a distinct species. It therefore is considered to be a *nomen dubium*.

V. alpestris Foissner, 1979 (p. 11).

V. amphitricha Schmarda, 1854 was described from a specimen in the process of telotroch formation. In the absence of a detailed description of a normal vegetative cell, it is now considered to be a *nomen dubium*.

V. amphiurae Cuénot, 1891 was described as having a straight spasmoneme which does not coil up in spiral fashion when it contracts. It should be therefore transferred to the genus *Haplocaulis*

V. anabaenae Stiller, 1940 was transferred to the genus *Haplocaulis* by Stiller (1971).

V. annulata (Gourret & Roeser, 1888) Kahl, 1935 was originally thought to be a variant of *V. brevistyla* but was elevated to the rank of species by Kahl (1935) (p. 13).

V. anomala Gourret & Roeser, 1886 (p. 13).

V. aperta Fromentel, 1874 (p. 13).

V. artemiae Lepsi, 1965. No diagram was given with this poorly described freshwater form which now becomes a *nomen dubium*.

V. astyliformis Foissner, 1981 (p. 13).

V. banatica Lepsi. The original reference could not be located but Stiller (1971) gives a detailed description and diagram of what appears to be a valid species (p. 14).

V. bidulphae Stiller, 1939 (p. 14).

V. bivacuolata Fukui & Morishita, 1961 (p. 14).

V. bosminae Šramek-Hušek, 1948 (p. 15).

V. brevistyla d'Udekem, 1864 was transferred to the genus *Pseudocarchesium* by Stiller (1971).

V. calciformis Kahl, 1933 (p. 15).

V. campanula Ehrenberg, 1831 (p. 15).

V. campanula f. *monilata* Stiller, 1963 has on its pellicle rows of regularly arranged tubercles and is therefore transferred to the genus *Pseudovorticella*.

V. campanula f. *minor* Stiller, 1953 is an epizooic variant of *V. campanula* and is not sufficiently distinct to be known by a separate name.

V. campanula f. *citrina* var. *minor* Stiller, 1953 = *V. campanula*.

V. campanulata (Kahl, 1933), Šramek-Hušek, 1948. This species was redescribed and renamed by Šramek-Hušek (1948) (p. 17).

V. carinogammari Stiller, 1953. Although redescribed by Piesik (1975) under that name it had already been transferred to the genus *Haplocaulis* by Stiller (1971).

V. chinensis Tai, 1931 strongly resembles *V. convallaria* but may be distinguished by its spheroidal macronucleus. However, Kirby (1942) has shown that *Vorticella* macronuclei also typically assume a round-oval shape if parasitised by bacteria. Therefore *V. chinensis* is considered to be a parasitised *V. convallaria*.

V. chlamydophora Penard, 1922 appears to be identical to *V. vestita* Stokes, 1883.

V. chlorellata Stiller, 1940 = *V. chlorostigma* Ehrenberg, 1831.

V. chlorostigma Ehrenberg, 1831 (p. 18).

V. chydoricola Šramek-Hušek, 1946 is an epizooic variant of *V. microstoma*.

V. citrina Müller, 1773 is, according to Fauré-Fremiet (1904), a physiological variant of *V. convallaria*.

V. citrina var. *turgescens* Stiller, 1931 = *V. convallaria*.

V. claparedei Andrussowa, 1886. The mode of contraction of this species suggests that it should be transferred to the genus *Haplocaulis*.

V. claudicans Penard, 1922 was transferred to the genus *Haplocaulis* by Stiller (1971).

V. coeni Lepsi, 1948 was so poorly figured and described that it cannot be recognised as a valid species. It therefore becomes a *nomen dubium*.

V. colorata Mereschkowsky, 1877 was distinguished on the basis of its pink cytoplasm but, according to Noland & Finley (1931), colour alone is insufficient for the separation of species. In the absence of other distinguishing features this species is now considered to be a *nomen dubium*.

V. communis Fromentel, 1874 (p. 18).

V. conica Dons, 1915. Kahl (1935) renamed this species *V. obconica* in order to solve the problem of homonymy with Stoke's (1887*b*) *V. conica*.

V. conosoma Stokes, 1889 was described by Gajewskaja (1933) who indicated that the spasmoneme is straight and that upon contraction the stalk folds rather than coils. Therefore this species is transferred to the genus *Haplocaulis*.

V. constricta Fromentel, 1874 = *V. microstoma*.

V. constricta Kahl, 1933 = *V. campanulata*.

V. constricta Gajewskaja, 1933 is clearly not a *Vorticella* since it forms colonies. Therefore, this species is transferred to the genus *Zoothamnium* and in order to prevent synonymy with *Z. constricta* it is renamed *Zoothamnium gajewskajum* nom. nov.

V. convallaria Linnaeus, 1758 (p. 18).

V. convallaria var. *compacta* Nenninger, 1948 is an epizooic form which only differs from *V. convallaria* by the arrangement of its food vacuoles. This feature was rejected by Noland & Finley (1931) as a basis for separating species.

V. costata (Sommer, 1951) Foissner, 1979 was originally thought to be a variety of *V. octava* but biometric studies by Foissner (1979) have shown that it is a distinct species (p. 19).

V. crassicaulis Kent, 1881 was transferred to the genus *Paravorticella* by Kahl (1935), and subsequently to the genus *Haplocaulis* by Stiller (1971).

V. crassicaulis Nenninger, 1948 appears to be identical to *V. longifilum* Kent, 1881. Synonymising these two also solves the problem of homonymy with the previous species.

V. cratera Kent, 1881 is the name which Kent applied to Ehrenberg's (1838) *V. patellina*. However, Kent's animal is quite unlike any other species of *Vorticella* and *V. cratera* is now designated as a distinct species (p. 20).

V. cupifera Kahl, 1935 appears to be identical to *V. microstoma*. Pratt & Rosen (1983) have also remarked on the similarity of these two species.

V. cyclopicola Kahl, 1935 is probably an epibiotic variety of *V. microstoma*.

V. cyclopis Kahl, 1933 is a marine form which closely resembles *V. convallaria*.

V. cylindrica Dons, 1915 appears to be a marine variety of *V. campanula*.

V. delicatulata Biernacka, 1963 is probably a marine variety of *V. hamata*.

V. difficilis Kahl, 1933 was transferred to the genus *Pseudovorticella* by Jankowski (1976).

V. dimorpha Stiller, 1940 (p. 20).

V. dipneumon Penard, 1922 was transferred to the genus *Haplocaulis* by Stiller (1971).

V. dubia Fromentel, 1874 was so poorly described and figured that it cannot be recognised as a distinct species. It therefore becomes a *nomen dubium*.

V. dudekemi Kahl, 1933 = *V. cratera*.

V. echina King, 1933 = *V. voeltzkowi* Sondheim, 1929.

V. eforiana Tucolesco, 1962. In the original diagram this species is shown as having a short, straight spasmoneme. It should therefore be transferred to the genus *Haplocaulis*.

V. elegans Dons, 1915 was transferred to the genus *Intranstylum* by Nenninger (1948), and later to the genus *Haplocaulis* by Stiller (1971).

V. elongata Fromentel, 1874 (p. 20).

V. ephemerae Kahl, 1935 is an epizooic form which closely resembles *V. convallaria*.

V. epizoica Šramek-Hušek, 1948 was transferred to the genus *Haplocaulis* by Stiller (1971).

V. exilis Nenninger, 1948 (p. 21).

V. extensa Kahl, 1935 was transferred to the genus *Haplocaulis* by Sommer (1951).

V. extensa var. *macronucleata* Nenninger, 1948 was transferred to the genus *Haplocaulis* by Stiller (1971).

V. fasciculata Müller, 1773 is distinguished principally on the basis of its green colouration, a character rejected by Noland & Finley (1931) for the separation of vorticellae. This is now considered to be a *nomen dubium*.

V. flexuosa Nenninger, 1948 (p. 21).

V. fluvialis Fromentel, 1874 is a morphological variant of *V. microstoma*.

V. floridensis Stokes, 1886 closely resembles and is probably synonymous with *V. kenti* (Kent, 1881) Kahl, 1935.

V. fromenteli Kahl, 1935 (p. 21).

V. fusca Precht, 1935 (p. 22).

V. fusca Biernacka, 1963. This species has a short, straight spasmoneme and should therefore belong to the genus *Haplocaulis*. This also solves the problem of homonymy with the previous species.

V. fusiforma Nenninger, 1948 was transferred to the genus *Haplocaulis* by Sommer (1951).

V. globosa Ghosh, 1922 (p. 22).

V. globularia Müller, 1773 (p. 22).

V. gracilis Dujardin, 1841 (p. 23).

V. granulata Kahl, 1933 (p. 23).

V. halophila Stiller, 1941 (p. 23).

V. hamata Ehrenberg, 1831 (p. 25).

V. hyalina Stiller, 1940 closely resembles and is probably synonymous with *V. convallaria.*

V. hyalina Stiller, 1968 was transferred to the genus *Zoothamnium* by Stiller (1971) which also solves the problem of homonymy with the previous species.

V. incerta Nenninger, 1948 is here synonymised with *V. ovum* Dons, 1918.

V. incisa Stiller, 1938 (p. 25).

V. inclinans Müller, 1786 was transferred to the genus *Opercularia* by Guhl (1972).

V. inconstantans Green, 1974 is variable in shape but when fully extended, closely resembles *V. lichenicola.*

V. iners Schrank, 1803 is so poorly described and figured that it is now considered to be a *nomen dubium.*

V. infusionum Dujardin, 1841 (p. 25).

V. intermissa Nenninger, 1948. The main distinguishing feature of this species is the spasmoneme which is incomplete, terminating a short distance below the zooid. However, this character is not accepted for separating species of *Vorticella.* In other respects *V. intermissa* closely resembles *V. pyriforme* Stiller, 1939 with which it is here synonymised.

V. jaerae Precht, 1935 (p. 26).

V. kahli Stiller, 1931 was transferred to the genus *Haplocaulis* by Sommer (1951).

V. kenti (Kent, 1881) Kahl, 1935 (p. 26).

V. latestriata Sommer, 1951 is a morphological variant of *V. striata* Dujardin, 1941.

V. latifunda Nenninger, 1948 (p. 26).

V. lichenicola Greeff, 1888 (p. 27).

V. lima Kahl, 1935 (p. 27).

V. limnetis Stokes, 1885 (p. 27).

V. lockwoodi Stokes, 1884 was synonymised with *V. margaritata* var. *chlorelligera* by Kahl (1935) which has since been transferred to the genus *Pseudovorticella* by Foissner & Schiffmann (1975).

V. longifilum Kent, 1881 (p. 29).

V. longifilum f. *epizooicum* Szczepanowski, 1978 is an epizooite which is not sufficiently distinct to be recognised as a separate taxon.

V. longimacronucleata Fukui & Morishita, 1961 = *V. microstoma* Ehrenberg, 1830.

V. longipharyngea Szczepanowski, 1978 closely resembles *V. subsinuata* Ghosh, 1922.

V. longiseta Dietz, 1964 (p. 29).

V. logitricha Gajewskaja, 1933 (p. 29).

V. lutea Stiller, 1938 (p. 30).

V. lymnaearum Viljoen & As, 1983 (p. 30).

V. macrocaulis Stokes, 1885 = *V. longifilum.*

V. macrophya Stokes, 1885 (p. 30).

V. macrostoma Schmarda, 1854 = *V. campanula.*

V. macrostyla Schmarda, 1854 (p. 30).

V. magna Fukui & Morishita, 1961 = *V. microstoma* Ehrenberg, 1830.

V. margaritata Fromentel, 1874 was transferred to the genus *Pseudovorticella* by Jankowski (1976).

V. margaritata var. *chlorelligera* Kahl, 1935 was transferred to the genus *Pseudovorticella* by Foissner & Schiffmann (1975).

V. marginata Stiller, 1931 (p. 31).

V. marginata f. *poliensis* Stiller, 1931 is, according to Szczepanowski (1978), an ecological variant of *V. marginata* which cannot be recognised as a separate taxon.

V. marginata f. *minor* Stiller, 1931 = *V. marginata* (Szczepanowski, 1978).

V. marina Greeff, 1870 (p. 31).

V. mayeri Fauré-Fremiet, 1920 (p. 31).

V. micata Kahl, 1933 has rows of regularly arranged pellicular tubercles and therefore belongs to the genus *Pseudovorticella.*

V. microscopica Fromentel, 1874 (p. 33).

V. microstoma Ehrenberg, 1830 (p. 33).

V. microstoma var. *defluviatilis* Nenninger, 1948 is a morphological variant of *V. microstoma.*

V. microstoma f. *elongata* Stiller (drawing and description in Stiller, 1971) = *V. microstoma.*

V. microstoma f. *monilata* Stiller (drawing and description in Stiller, 1971) was transferred to the genus *Pseudovorticella* and renamed *P. papillata* by Jankowski (1976).

V. microstoma f. *turgescens* Stiller (drawing and description in Stiller, 1971) = *V. microstroma.*

V. minima Stiller, 1939 is probably an epizooic variety of *V. striata* Dujardin, 1841.

V. minuta Precht, 1935 = *V. marina* Greeff, 1870.

V. molesta Stokes, 1889. In the original description this species was not figured and was so poorly characterised that it cannot be recognised as a distinct species. It therefore becomes a *nomen dubium*.

V. mollis Stokes, 1887 has rows of regularly arranged pellicular tubercles and is therefore transferred to the genus *Pseudovorticella*.

V. monilata Tatem, 1870 was transferred to the genus *Pseudovorticella* by Foissner & Schiffmann (1974).

V. mortensi Dons, 1922 was described from fixed material and is therefore considered to be a *nomen dubium*.

V. muralis Penard, 1922 (p. 34).

V. mutans Penard, 1922 was transferred to the genus *Pseudovorticella* by Foissner (1979).

V. nana Kahl, 1933 is probably a marine variety of *V. subprocumbens* Ghosh, 1922.

V. natans (Fauré-Fremiet, 1924) Kahl, 1935 (p. 34).

V. nebulifera Müller, 1773 was transferred to the genus *Pseudovorticella* by Jankowski (1976).

V. nutans Muller, 1773 (p. 34).

V. obconica (Dons, 1915) Kahl, 1935 (p. 35).

V. oblonga Kirk, 1887 was not figured and only poorly described by the original author. It is therefore considered to be a *nomen dubium*.

V. oceanica Zacharias, 1906 = *V. striata*.

V. octava Stokes, 1885 is a freshwater variety of *V. striata*.

V. octava var. *asellicola* Stiller, 1953 has an unstriated pellicle and is clearly not a variety of *V. octava*. However, it closely resembles, and may be synonymous with, *V. rotunda* Nenninger, 1948.

V. octava f. *costata* Sommer, 1951 was redescribed by Foissner (1979) who elevated it to the rank of species as *V. costata*.

V. operculariformis Foissner, 1979 (p. 35).

V. ophiocomae Giard, 1879. In the original description this species was not figured and was so poorly characterised that it cannot be recognised as a distinct species. It is now considered to be a *nomen dubium*.

V. ovum Dons, 1918 (p. 35).

V. parasita Stokes, 1887 (p. 37).

V. partita Fukui & Morishita, 1961 = *V. microstoma*.

V. patellina Müller, 1776 (p. 37).

V. patellina Ehrenberg, 1838 is a freshwater species which is clearly different from Müller's (1776) *V. patellina*. Noland & Finley (1931) considered this to be a shallow variety of *V. campanula*.

V. pelagica Gajewskaja, 1933 was transferred to the genus *Haplocaulis* by Stiller (1971).

V. perlata Kahl, 1933 = *V. punctata* Dons, 1918.

V. picta Ehrenberg, 1838 (p. 37).

V. pileolata Lepsi, 1948 = *V. microstoma*.

V. platysoma Stokes, 1887 (p. 38).

V. plicata Gourret & Roeser, 1886 is probably a marine variety of *V. elongata*.

V. plicata Szczepanowski, 1978 is a freshwater epizooite and is clearly different from Gourret & Roeser's (1886) *V. plicata*. In order to solve the problem of homonymy, this species is renamed *V. szczepanowskii* nom. nov.

V. poznaniensis Piesik, 1976 (p. 38).

V. procera Nenninger, 1948 was transferred to the genus *Haplocaulis* by Stiller (1971).

V. pulchella Sommer, 1951 (p. 38).

V. pulchra Kahl, 1933 (p. 38).

V. punctata Dons, 1918 has rows of regularly arranged pellicular tubercles and should therefore be transferred to the genus *Pseudovorticella*.

V. putrina Müller, 1776 is not a *Vorticella* as it possesses a rigid, non-contractile stalk. It is therefore transferred to the genus *Rhabdostyla* and becomes *Rhabdostyla putrina* comb. nov.

V. pyriforme Stiller, 1939 (p.39).

V. pyrum collaris Wang Jiaji, 1974 = *V. striata*.

V. quadrangularis Kent, 1881 (p. 39).

V. rhabdophora Stokes, 1885 (p. 39).

V. robusta Dons, 1922 was described from contracted specimens and until healthy, uncontracted cells have been observed this cannot be recognised as a valid species. It therefore becomes a *nomen dubium*.

V. rotunda Nenninger, 1948 (p. 41).

V. rotunda var. *asellicola* Stiller, 1953 = *V. rotunda*.

V. rubristigma Kellicott, 1888 (p. 41).

V. salina Stokes, 1887 was considered by Noland & Finley (1931) to be a freshwater variety of *V. nebulifera* (= *V. convallaria* according to Reid, 1967).

V. sepulcreti Foissner & Schiffmann, 1975 (p. 41).

V. similis Stokes, 1887 was considered by Noland & Finley (1931) to be a freshwater variety of *V. nebulifera*. Reid (1967) has now shown that *V. nebulifera* var. *similis* is a morphological variety of *V. convallaria*.

V. simplex Nenninger, 1948 closely resembles *V. longifilum*.

V. singularis Kahl, 1933 = *V. verrucosa* Dons, 1915.

V. smaragdina Stokes, 1885 is distinguished by its green colouration, a feature which was rejected by Noland & Finley (1931) for separating species. It now becomes a *nomen dubium*.

V. solitaria Stiller, 1935 closely resembles *V. subprocumbens* Ghosh, 1922.

V. spectrabilis Kent, 1881 is a distinct species which Kahl (1935) renamed *V. kenti* in order to solve the problem of homonymy with Bory's (1824) *V. spectrabilis*.

V. sphaerica d'Udekem, 1864 = *V. globularia*.

V. striata Dujardin, 1841 (p. 41).

V. striata var. *octava* (Stokes, 1885) Noland & Finley, 1931 was the name which Noland & Finley (1931) applied to Stokes' (1885) freshwater variety of *V. striata*. It is no longer recognised as a separate taxon.

V. striata var. *octava* f. *utriculus* Szczepanowski, 1978 = *V. infusionum*.

V. subconica Stiller, 1946 appears to be identical to *Vorticella* (*Pseudovorticella*) *punctata*.

V. subcylindrica Ghosh, 1922 appears to be synonymous with *V. elongata* Fromentel, 1874.

V. submicrostoma Ghosh, 1922 = *V. microstoma*.

V. suboctava Sommer, 1951 is an epizooic variety of *V. striata*.

V. subprocumbens Ghosh, 1922 (p. 42).

V. subsinuata Ghosh, 1922 (p. 43).

V. subsphaerica Dons (1915) 1918 is probably a morphological variety of *V. communis*.

V. szczepanowskii (Szczepanowski, 1978) nom. nov. for *V. plicata* Szczepanowski, 1978 (p. 43).

V. telescopica Kent, 1881 (p. 43).

V. telescopica Kahl, 1935 was renamed *V. telescopoides* by Šramek-Hušek (1948*b*) in order to prevent homonymy with the previous species.

V. telescopica var. *marina* is a marine variety of Kent's (1881) *V. telescopica*.

V. telescopiformis (Gourret & Roeser, 1886) Kahl, 1935 = *V. telescopica* Kent, 1881.

V. telescopoides (Kahl, 1935) Šramek-Hušek, 1948 (p. 44).

V. teninucleata Dons, 1922 is a poorly characterised marine species which was described from contracted specimens. It therefore becomes a *nomen dubium*.

V. turgicula Wang Jiaji, 1977 (p. 44).

V. undulata (Dons, 1918) Kahl, 1935 has a short, straight spasmoneme and was originally called *Vorticellopsis undulata*. It was so poorly described that it is now regarded as a *nomen dubium*.

V. urceolus Biernacka, 1963 is probably a morphological variety of Stiller's (1953*b*) *V. carinogammari* (= *Haplocaulis carinogammari*).

V. urnula Nenninger 1948 closely resembles *V. globosa*.

V. utriculus Stokes, 1885 is probably a variant of *.V infusionum*.

V. variabilis Stiller, 1939 is probably a marine variety of *V. bidulphae*.

V. venusta Nenninger, 1948 (p. 44).

V. vernalis Stokes, 1887 (p. 45).

V. verrucosa Dons, 1915 (p. 45).

V. vestita Stokes, 1883 (p. 45).

V. voeltzkowi Sondheim, 1929 (p. 47).

V. zooanthelligera Stiller, 1968 has rows of regularly arranged pellicular tubercles and should therefore be transferred to the genus *Pseudovorticella*.